Inside: Bonus Graphics Supplement (follows page 248)

BYTE

APRIL 1989

A McGRAW-HILL PUBLICATION

REVIEWS

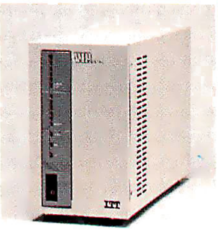
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THE DELL 386 SYSTEM 325 HAS A 25 MHz CLOCK RATE, CACHE MEMORY CONTROLLER, 90 MB 18ms ESDI DRIVE, PAGE MODE INTERLEAVED MEMORY, AND 100% COMPATIBILITY WITH MS-DOS, OS/2 AND UNIX SYSTEM V.

Technically speaking, the System 325 is the most advanced 386™ computer we've ever built. And, according to PC Magazine, it's one of the most advanced 386 computers they've ever tested.

In benchmark after benchmark, the Dell System 325 25 MHz ran circles around a field of 386-based systems. A field that included the Compaq^ 386/25.

A show of prowess that earned the System 325 PC Magazine's Editor's Choice award.

It was a goal we set for ourselves from the very beginning. And an objective anyone with a penchant for power and performance can appreciate.

A PERSONAL COMPUTER THAT'S REALLY PERSONAL.

Of the more than 150,000 personal computers we've sold to date, each one's been individually configured to fit the needs of its owner.

The System 325 takes that idea to its logical extreme.

For example, it runs either MS-DOS®, OS/2, or our own Dell UNIX® System V. Which is compatible with AT&T's System V Interface Definition. And the world of XENIX® applications.

If speed is of the essence, we can include an optional Intel^ 80387 or WEITEK 3167 math coprocessor. And since nothing about this system is lightweight, the standard mass storage is a 90 MB ESDI disk drive. Or we can configure it with a 150 or 322 MB unit.

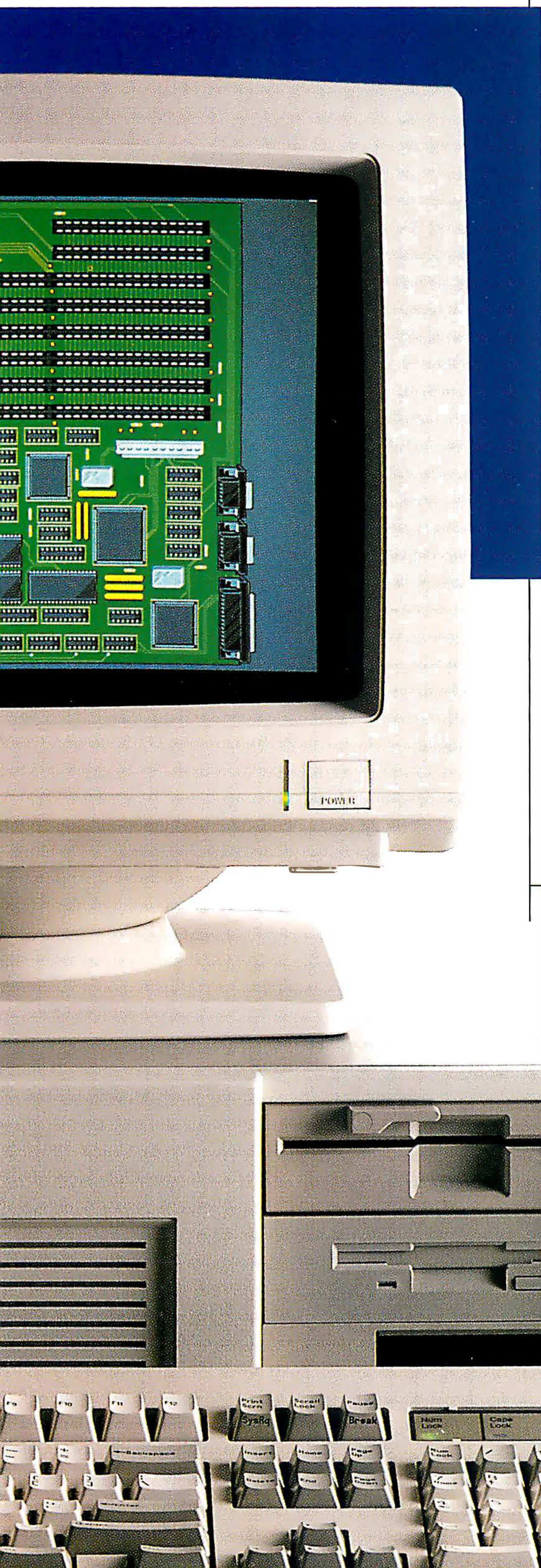
As you might expect, the output is just as intense. You can choose between VGA mono with paperwhite screen, or VGA Color



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All Dell laser printers come with 1.5 MB RAM, full-page 300 DPI graphics, and have 31 standard fonts (7 resident and 24 downloadable from diskette). Dell laser printers also provide Hewlett-Packard LaserJet Plus,^ Epson/FX,^ IBM Proprinter^ and Diablo 630^ emulations.





THE DELL SYSTEM 310
20 MHz 386.

The best combination of performance and value available.

STANDARD FEATURES:

- Intel 80386 microprocessor running at 20 MHz.
- Choice of 1 MB or 4 MB of RAM* expandable to 16 MB using a dedicated high speed 32-bit memory slot.
- Advanced Intel 82385 Cache Memory Controller with 32 KB of high speed static RAM cache.
- Page mode interleaved memory architecture.
- VGA systems include a high performance 16-bit video adapter.
- Socket for 20 MHz Intel 80387 or 20 MHz WEITEK 3167 math coprocessor.
- 5.25" 1.2 MB or 3.5" 1.44 MB diskette drive.
- Dual diskette and hard disk drive controller.
- Enhanced 101-key keyboard.
- 1 parallel and 2 serial ports.
- 200-watt power supply.
- 8 industry standard expansion slots.

OPTIONS:

- 20 MHz Intel 80387 math coprocessor.
- 20 MHz WEITEK 3167 math coprocessor.
- 1 MB or 4 MB RAM upgrade kit.
- 2 MB or 8 MB memory expansion board kit.

***Lease for as low as $141/Month.*

System 310 — With Monitor & Adapter

Hard Disk Drives	VGA Mono 1 MB RAM	VGA Mono 4 MB RAM	VGA Color Plus 1 MB RAM	VGA Color Plus 4 MB RAM
40 MB-28 ms	$3,899	$5,199	$4,199	$5,499
90 MB-18 ms ESDI	$4,699	$5,999	$4,999	$6,299
150 MB-18 ms ESDI	$5,199	$6,499	$5,499	$6,799
322 MB-18 ms ESDI	$7,199	$8,499	$7,499	$8,799



THE DELL SYSTEM 220
20 MHz 286.

It's fast as most 386 computers. But at less than half the price. The footprint is small, too.

STANDARD FEATURES:

- 80286 microprocessor running at 20 MHz.
- 1MB of RAM* expandable to 16MB (8 MB on system board).
- Page mode interleaved memory architecture.
- LIM 4.0 support for memory over 1 MB.
- Integrated diskette and VGA video controller on system board.
- Socket for Intel 80287 math coprocessor.
- One 3.5" 1.44 MB diskette drive.
- Integrated high performance hard disk interface on system board.
- Enhanced 101-key keyboard.
- 1 parallel and 2 serial ports (integrated on system board).
- 3 full-sized industry standard expansion slots available.

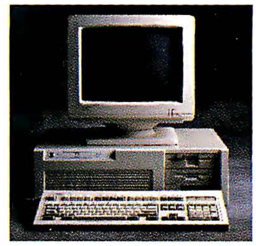
OPTIONS:

- External 5.25" 1.2 MB diskette drive.
- 3.5" 1.44 MB diskette drive.
- Intel 80287 math coprocessor.
- 1 MB or 4 MB RAM upgrade kit.

***Lease for as low as $86/Month.*

System 220 — With Monitor

Hard Disk Drives	VGA Mono	VGA Color Plus
One Diskette Drive	$2,299	$2,599
40 MB-29 ms Hard Disk	$2,999	$3,299
100 MB-29 ms Hard Disk	$3,799	$4,099



THE DELL SYSTEM 200
12.5 MHz 286.

This full-featured 286 computer runs at 12.5 MHz, and is completely Microsoft MS-DOS and MS OS/2 compatible.

STANDARD FEATURES:

- 80286 microprocessor running at 12.5 MHz.
- 640 KB of RAM expandable to 16 MB (4.6 MB on system board).
- Socket for Intel 80287 math coprocessor.
- 5.25" 1.2 MB or 3.5" 1.44 MB diskette drive.
- Dual diskette and hard disk drive controller.
- Enhanced 101-key keyboard.
- 1 parallel and 2 serial ports.
- 200-watt power supply.
- 6 industry standard expansion slots.

OPTIONS:

- Intel 80287 math coprocessor.
- 512 KB RAM upgrade kit.
- 2 MB RAM upgrade kit.

***Lease for as low as $93/Month.*

System 200 — With Monitor & Adapter

Hard Disk Drive	VGA Mono	VGA Color Plus
40 MB-40 ms	$2,499	$2,799
40 MB-28 ms	$2,699	$2,999
90 MB-18 ms ESDI	$3,499	$3,799
150 MB-18 ms ESDI	$3,999	$4,299
322 MB-18 ms ESDI	$5,999	$6,299

****Performance enhancements (Systems 325, 310 and 220): Within the first megabyte of memory, 384 KB of memory is reserved for use by the system to enhance performance.***



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We offer a complete line of software. Everything from complex CAD/CAM applications to fun flight simulator programs. All at extremely competitive prices.

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BEST OF ALL, YOU WON'T HAVE TO EXPLAIN TO A COMPUTER RETAILER WHAT ALL THAT MEANS.

Plus, for high resolution colors displayed on a larger screen.

Even though the 325 gives you all this performance, it still leaves you six open slots for whatever else you might want to add.

And once you've told us what you want, we'll make sure what you want works—by burning-in the entire system unit.

COMPUTER RETAILERS ARE NO KNOWS.

In all probability, the average computer retailer won't have any understanding what makes the System 325 go.

He will, however, be quite aware of the fact that he could add a 35% markup if he could sell it in his store.

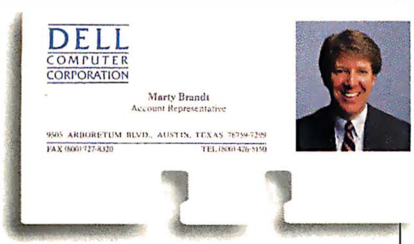
Which he can't.

Because we sell direct.

Meaning you now have the unique opportunity to talk directly with a computer expert. And ask things like, "What's the difference between IDE and ESDI?" Or, "How much SIMM RAM should I add?"

In other words, the kinds of questions you should be able to ask a retailer, but usually can't.

So as you might suspect, dealing direct not only saves you the 35% markup, but 100% of the aggravation.



WE COME WHEN WE'RE CALLED.

One of the things that very clearly sets a Dell system apart from other computers is not just how they're sold, but how they're supported.

Overkill was one description used in a recent PC Week article.

Perhaps.

But then, we think you'll agree, when something goes wrong, you want as much help as possible, right?

Which is why every Dell system comes with a toll-free technical support line and self-diagnostic software. We're able to solve 90% of all problems right over the phone. The other 10% receive next-day, deskside service.

And you get all this help for a full year—whenever you need it—at no extra charge.^

As you've probably guessed, one of the things that drives us most is customer satisfaction.

So we'd like to give you the ultimate guarantee: Try a System 325 in your office for a month. Run your toughest applications. Put it through its paces, at your pace. If you're not completely satisfied, send it back anytime within 30 days. And we'll refund your money.

No questions asked.

MAYBE YOU SHOULDN'T BUY ONE AFTER ALL.

No matter how many reasons we give you to buy a Dell system, sometimes it makes more sense to lease one instead.

Whether you need a single computer, or an entire office full, our leasing plan is just like 100% financing. So you don't tie up working capital. Or credit lines.

Of course, there can be tax advantages as well.

And just as we can custom configure your computers, we can fit a lease plan to the exact needs of your business. A fact that has not gone unnoticed. Especially by the Fortune 500. Over half of whom now own or lease Dell systems.

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That's the part we like best.

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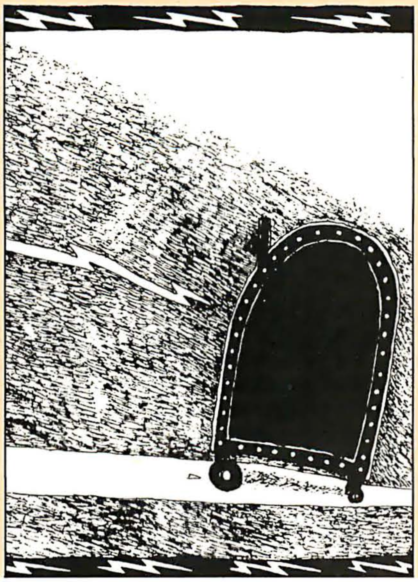
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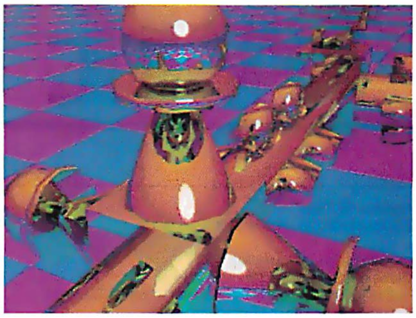
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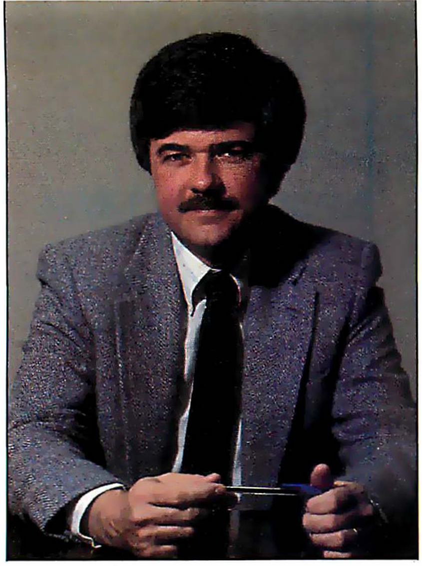
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EDITORIAL ■ Fred Langa

OPEN EVERYTHING

GUIs, grails, embedded processors, and one-station radios

We frequently get visitors here at BYTE. People come to demonstrate new products, to find out more about our editorial content and policies, and sometimes just to meet the folks who put out the magazine. It's always a pleasure to talk to the visitors, and it's always good to exchange information and gain insights on what's happening in the industry.

Sometimes, these insights arrive in unexpected ways.

For example, after a tour of our Lab and editorial facilities, one recent visitor was puzzled at the large number of different computing environments he'd seen: SunView, Windows, the Macintosh's Desktop, OS/2's Presentation Manager, Open Look, Next Step, and Open Software Foundation's Motif all were either up and running, or had been running and were now visible as slides and screen shots lying around various offices.

"They all look the same," the visitor said. "It's getting hard to tell them apart."

Indeed. Oh, there are real, substantive differences among these environments. The internal variances are enough to turn a systems programmer prematurely gray. And as for on-screen differences, well, these three interfaces have three-dimensional highlighting of the user-selectable buttons, this one has tear-off menus, that one has virtual pushpins. . . .

But focusing on these differences is equivalent to "looking at the trees," while our visitor was commenting on a forest of remarkably uniform vegetation. From an end user's perspective, the differences among the top-of-the-line graphical user interfaces (GUIs) are overshadowed by the many similarities.

In some very real ways, today's best GUIs have attained the long-sought grail: They are alike enough to be generally familiar, even at first sight. Most people (certainly most BYTE readers) can sit down and start poking their way around one of these advanced GUIs without a lot of trouble. No, these GUIs aren't perfect, but they've gone a long way toward knocking down the walls separating different machines and operating systems.

This breaking down of walls has profound implications for the hardware and software we'll be using in the future. Even so, it's only part of an even larger trend toward openness. To continue the analogy, just as the walls are breaking down, so are the ceilings.

The old distinctions between workstations and microcomputers have totally vanished. You can't tell the difference anymore between a high-end microcomputer and a low-end workstation because there is no difference, as our 50-page supplement on personal workstations last February indicated.

And, just as the walls and ceilings are breaking down, so are the floors: A computer is no longer just the box on your desk. Computers are also powerful processors invisibly embedded in numerous products, from laser printers to network controllers and beyond. Our fundamental definition of "what is a computer" will soon have to change.

I'm not talking about the glorified digital clock mounted in a Mr. Coffee: Intel says that as recently as last year, 30 percent of all top-of-the-line 80386 chips were installed in products not traditionally thought of as "computers." (Motorola tells a similar story.) The demand was so strong that Intel designed a variant of the 80386 just for embedded applications; it's called the 80376 and is a close cousin to the 80386SX.

So, the walls, the ceilings, and the floors of computing are all vanishing. What's left?

A new openness. In fact, an astonishing openness. Some of it is so blatant that it hits you over the head: Open Token, Open Look, Open View, Open Link, Open Software Foundation, and Open Systems Interconnect; Open this and Open that.

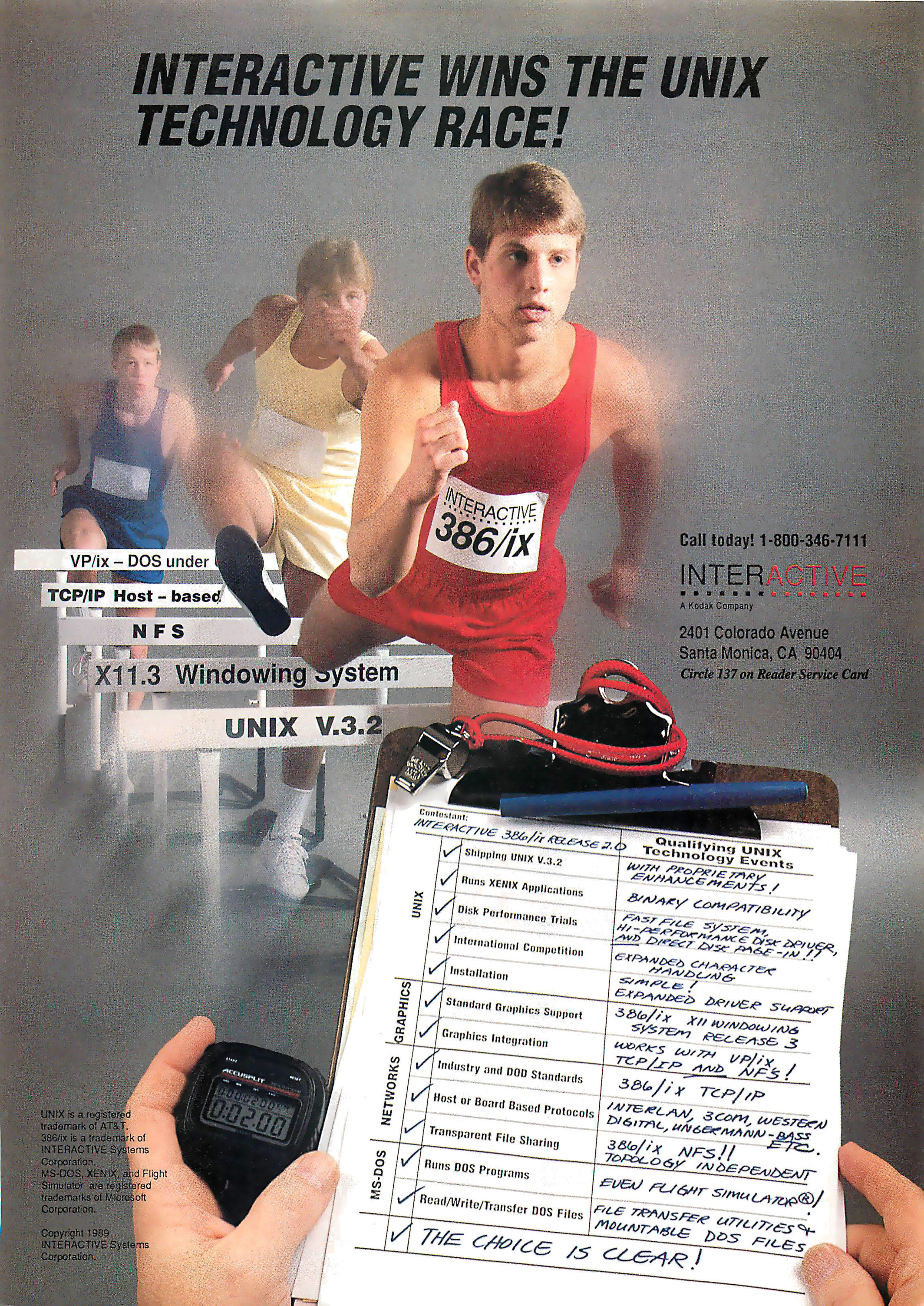
A bit more subtly, there are hardware developments like EISA (Extended Industry Standard Architecture), which will try to keep at least a piece of the 32-bit bus market open; and software developments like the wide acceptance of XWindows, SQL (Structured Query Language), RenderMan, and PostScript and its clones—which, while not fully open, serve somewhat the same purpose by being *lingua francas* of the microcomputing software world.

The trend to extreme openness in official and de facto standards is happening faster and spreading far more widely than most people predicted. And there's no slowdown in sight—standards themselves are starting to merge.

For example, XWindows is gaining three-dimensional graphics by merging with PHIGS—the Programmer's Hierarchical Interactive Graphics System, itself an internationally accepted standard for three-dimensional graphics. This hybrid of the two separate standards will be bundled, along with other extensions to XWindows, in a package called PEX.

So, the trend is crystal clear: Nowadays, the old, easy, one-brand or one-standard solutions to microcomputing problems make about as much sense as one-station radios: You may get that one station very well, but you'll be missing a world of other, possibly better, options. To master today's mixed microcomputing environment, you need information on the full spectrum of possibilities—and that's what BYTE is all about. There's no room for closed minds in today's open environments.

—Fred Langa
Editor in Chief
(BIX name "flanga")



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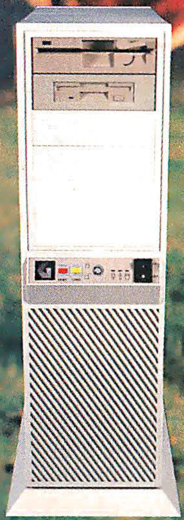
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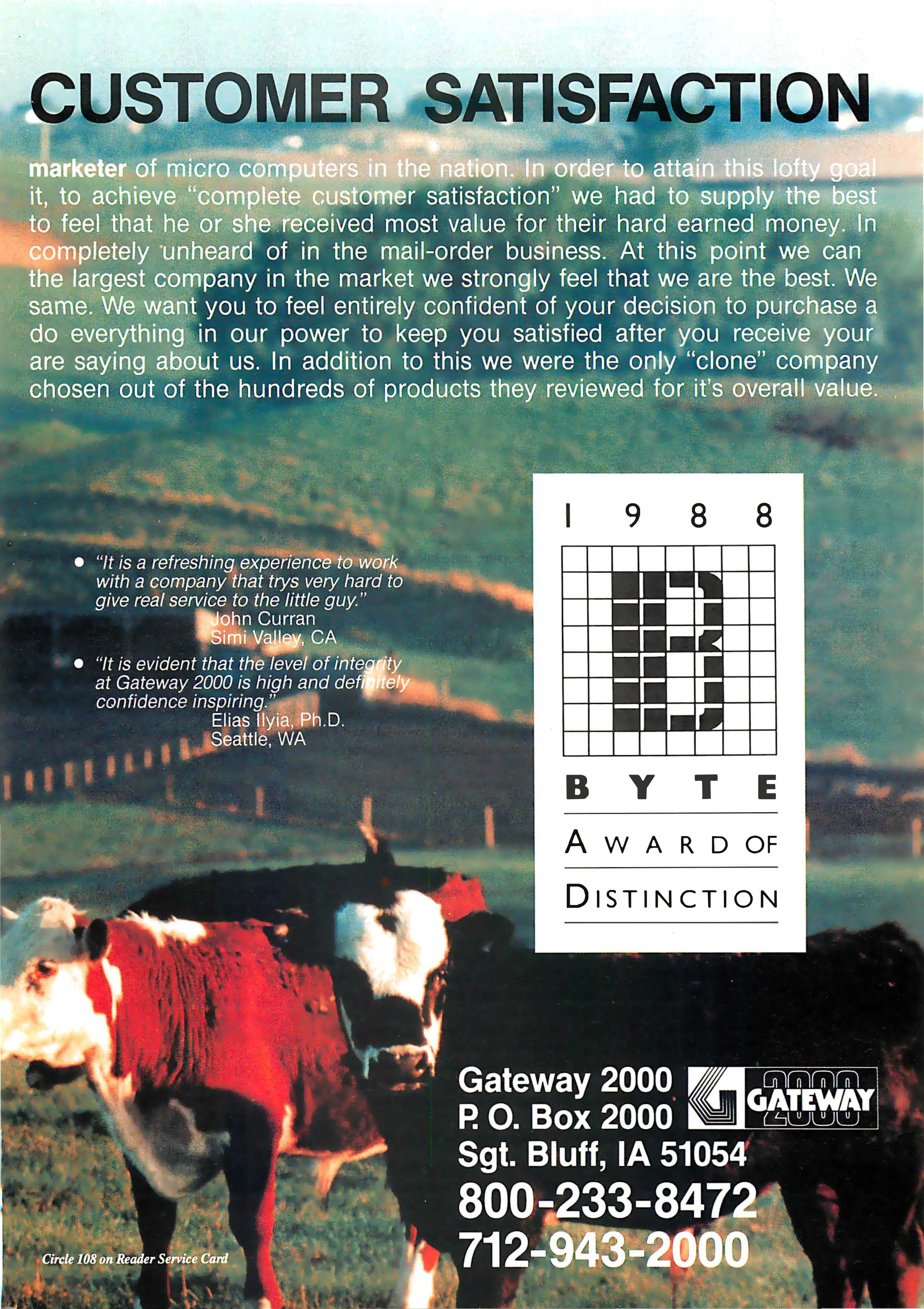


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Vermont Views is available for DOS, OS/2, UNIX, XENIX, and VMS. Maintain the same user interface on all of these operating systems with the same source code.

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Staff-written highlights of developments in technology and the microcomputer industry, compiled from Microbytes Daily and BYTEweek *reports*

Intel's New 80860 CPU Aims to Be a Cray on a Chip

Amid all the speculation over Intel's forthcoming 80486 chip were rumors that it was powerful enough to become the heart of a minicomputer or even a future mainframe. Now it looks as though the subject of those rumors wasn't the 80486 after all, but another new Intel CPU—one that's designed to be a microprocessor version of a Cray supercomputer.

The new 80860 (or i860) came out from under wraps at the end of February, but engineers at the IEEE International Solid-State Circuits Conference in New York got a sneak preview two weeks before the official debut. Code-named "N-10" while under development, the 80860 is a 64-bit RISC CPU containing one million transistors and running at up to 50 MHz.

Most current RISC processors use several chips; SPARC CPUs, for example, use five different chips, and Motorola's 88000 consists of a three-chip set, including instruction and data caches. But the 80860 has them all on a single chip. One-third of the CPU consists of the data and instruction caches; another third handles integer instructions; and a final third comprises the floating-point adder and multiplier units. Intel says the on-chip caches allow a data transfer rate of nearly 1 gigabyte per second, far faster than is possible with external cache chips. And the three separate FPUs can work in parallel, meaning as many as 120 million operations per second at 40 MHz.

Still more interesting, according to members of the 80860 design team, is the fact that the FPUs are modeled after Cray's pipelined vestor architecture. When a series of identical floating-point operations is performed on a collection of data, the chip doesn't have to wait for the first calculation to finish before beginning work on the second calculation. The FPUs are designed to work in stages, so they perform each part of a lengthy floating-point operation separately and then send the result down the pipeline to the next stage. (The separate adder and multiplier can even be configured to automatically send the results of one FPU to the other for more processing.) That translates into extraordinarily fast vector processing. Intel claims that the 80860 runs at better than 85,000 Dhrystones per second, which would be about twice as fast as the next quickest RISC chip available (one company's 33-MHz version of Sun's SPARC chip has been clocked at 40,000 Dhrystones per second).

The chip also includes three-dimensional graphics hardware for Gouraud and Phong shading. It's as a graphics coprocessor that Intel will initially market the chip, and the company expects to see it appearing by late this year on add-in boards for graphics workstations.

Fabrication on the 80860 is 1-micron static CMOS, which means you can stop the clock without losing anything. Intel already has FORTRAN-77 and C compilers for the chip, and Unix version 4 is supposed to be ready by the end of the year. When we spoke with Intel right before press time, the company was quoting quantity prices of $750 for end-of-the-year delivery.

Does the introduction of the 80860 mean that Intel is abandoning the world of 80x86 processors? Hardly. The 80486 is scheduled to be out by the end of this year, and Intel officials believe that the IBM PC-compatible line still has plenty of life in it. The 80860's future may be as part of a superminicomputer, with multiple 80860 CPUs running Unix; such a machine could show up sometime next year. But that doesn't mean the new chip couldn't show up in personal computers, as well; an 80860 and 8 megabytes of RAM would easily fit on an IBM PC AT-style plug-in card. Cray-in-a-box, anyone?

New "Mainstream" Mac II: Three NuBus Slots, Less Filling

Last month, Apple Computer introduced yet another member of its growing family of Macintosh II systems, a model that CEO John Sculley described as the "mainstream" machine of the Macintosh II "modular product line." This one, called the Macintosh IIcx (at least that's how Sculley referred to it when Apple gave us an early look), features three NuBus expansion slots

continued

NANOBYTES

• Mach Three: Unix software house **Mt Xinu** (Berkeley, CA) plans to develop versions of Carnegie-Mellon University's **Mach multiprocessing operating system** for three workstation environments: **Sun-3, DEC VAX, and IBM RT PC**. Mt Xinu says its versions will be binary-compatible with Berkeley Unix 4.3, will adhere to "standard interfaces such as Posix, and will also incorporate Carnegie-Mellon's Andrew software and MIT's X Window system." Releases are slated to start early next year, the company says.

Mach acquired some commercial glamour last October when Steve Jobs introduced the NeXT computer, which incorporates the Mach kernel. (For more on Mach, see the November 1988 BYTE cover story on the NeXT system.)

• The jaded ones who said they saw nothing new at the recent **Mac-World Expo** in San Francisco must have missed the **WristMac**, a Seiko-built digital watch that **connects directly to a Mac serial port via a special cable** for uploading or downloading information.

The watch holds up to 80 two-line displays of 12 characters each, which you can edit on either the Mac or the watch. Push a button, and the Wrist-Mac will cycle through up to a dozen files you've

continued

NANOBYTES

created. Each file can contain up to 79 entries. Files can be timed alarms that display a message, names or phone numbers, or any other text the user enters or downloads. It's $225 for the standard black WristMac. A $295 "executive version" comes with a water-resistant metal case, gold buttons, and a one-piece metal wristband; it's glitzy, but no one will mistake it for a Rolex. From Ex Machina, of New York City.

• **Hitachi Ltd.** of Japan has developed a **semiconductor laser** that acts as a light source for "very **high-speed optical** communications systems." The laser has a proprietary new structure that comprises an "organic insulating film embedded in the semiconductor element," a spokesperson said in an interview with Microbytes Daily.

The semiconductor laser operates on a single line spectrum that allows it to transmit 16 gigabits of information per second over long distances "without waveform distortion," the spokesperson said. The laser is seen as a key component in the development of a high-speed optical transmission system to link geographically distributed computers. The new semiconductor also has its place in the ongoing development of video phones and high-definition TV (HDTV) image transmission systems.

• **Microtec Research** (Santa Clara, CA) has a new **high-level debugger for the Zilog Z80 processor**. The

continued

instead of the six slots available in the Mac II and Mac IIx. The Mac IICx has the same 16-MHz Motorola 68030 processor as the Mac IIx; and we found no difference in performance between it and the Mac IIx. However, the new system comes in a smaller box—the footprint is about 12 by 15 inches. Although it's more compact, the Mac IICx's logic board has the same circuitry as the Mac IIx, including the 256K-byte single in-line memory module ROM and the Floppy Disk High Density internal floppy disk drive controller, which can read and write MS-DOS, OS/2, and Apple II 3½-inch floppy disks.

The newest Mac features a modular design reminiscent of the IBM PS/2 series. The cover, power supply, and drive housings have snap fittings made of high-strength plastic, so you can disassemble the entire machine in a few minutes. The machine has a quiet 90-watt power supply (in contrast to the 220-W power supply of the Mac II and IIx) and two 3½-inch bays for a floppy disk drive and a hard disk drive (the Mac II and IIx have 5¼-inch bays that can also be used for 3½-inch drives). Other changes include an external DB-19 serial port for connecting an external floppy disk drive and an auto-restart capability so that the machine automatically reboots in the event of a power outage.

At press time, Apple had not yet specified prices or configuration options for the Mac IICx. However, Sculley said the Mac IICx would cost roughly the same as the Mac IIx (basic unit, $6969; with an 80-megabyte hard disk drive, $7869). Sculley said it's roughly an equal trade-off to swap three slots and a small box for the six slots and larger footprint of the Mac IIx.

Apple also brought out a new 15-inch portrait-oriented gray-scale monitor with 640- by 870-pixel resolution, and a 21-inch gray-scale monitor offering 1152- by 870-pixel resolution. Both come with a Mac II video card that can be configured with either 2-bit or 4-bit pixel depth (allowing display of 4 or 16 shades of gray, respectively).

Apple also announced a 160-megabyte 5¼-inch hard disk drive (Model 160SC) for the Mac II and IIx. The 160SC does not fit into the new Mac IICx's hard disk bay.

We'll have more details and photographs of the newest Mac in the May issue of BYTE.

"Location Transparency" Next Hurdle for Database Technology

They don't care where it is; they just want to get there. Database users say their biggest concern is access to data—data scattered across several computers that don't talk to each other. A few computer companies are firing up their efforts to make access an easy, invisible process. Most of these companies are focusing on the mainframe level, but many of the techniques they develop will wind up on microcomputers within the next few years. IBM, for example, is working on the concept of "location transparency" for its DB2 relational database system, says Jnan Dash, manager of Data Systems Strategy at IBM.

Location transparency would mean that an end user could access data without knowing where the data resides on the database network, which could include machines running AIX, OS/2, and IBM's mainframe VM operating system. An engineer at an airplane manufacturer working on an AIX-based CAD workstation, for example, would be able to transparently call up some data from an IBM 370-based mainframe running VM.

The basis for location transparency is the idea of the distributed database, which is finally starting to become a real technology. The client/server model is "old hat," according to DEC product architecture manager Barry Rubinson. Rubinson says "interoperation" in a "mixed vendor shop" will become the standard environment in the next few years and that database vendors will have to provide the tools that allow their products to transparently access data stored under other vendors' database products. The key, he says, will be the standardization of Structured Query Language. The current chaos in SQL standards will change in the next few years, he says. "Right now, SQL usually means you have a SELECT statement in your database language." However, Rubinson predicts that a standard for SQL will emerge by 1991.

Performance is the least concern of database software buyers, according to vendors, corporate planners, and consultants at the recent DB/Expo in San Francisco. What buyers are most concerned with is the ability to work transparently with diverse and remote systems and to have a data typing scheme that is fluid enough to handle complex objects like airplane diagrams, digitized photos, and recorded speech.

"Mixed environments

continued

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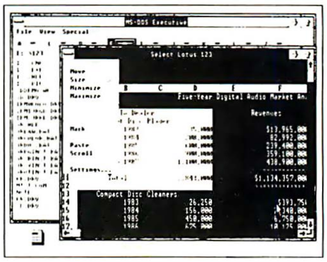
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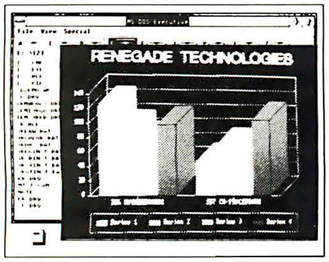
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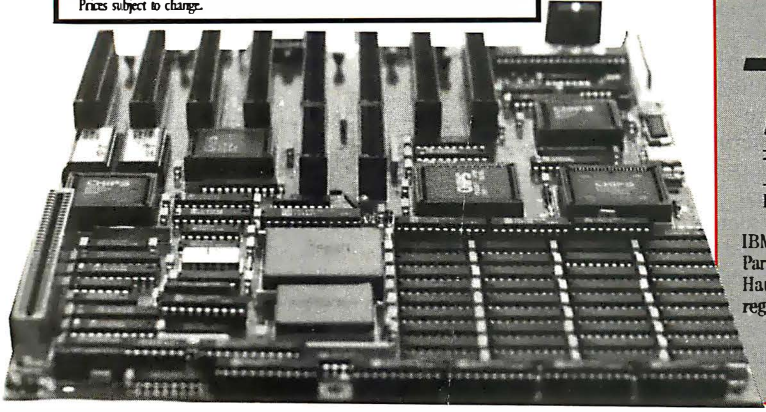
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are the real environments," says Martin Sprinzer of Relational Technology. "We must get to data no matter where it resides," and this process should be transparent to the user. For corporate database users, that means transparent no matter what the location, data format, operating system, or user interface.

Distributed databases and gateways are seen as part of the answer. But as database guru C. J. Date puts it, there are some very difficult problems associated with distributed systems. To maintain data integrity in a distributed system, for instance, various data replication schemes have evolved. All of them require a tradeoff, said Date, between data protection (during retrievals or updates) and performance. An emerging technique called *snapshots* essentially takes a "picture of the database" that can be used in read-only mode while other users can continue using the database. Snapshots might be promising, Date says, because they offer "some of the functionality of replication but without some of the headaches."

Another important advance we heard forecast at DB/Expo involves extensions to the relational database model, which will allow for object-oriented data, such as a document data type or a drawing or image data type. Experts at the conference also said I/O performance of transaction processing is speeding up considerably, approaching 2.5 I/O cycles per transaction (the rate has traditionally been 10 to 20 I/O cycles per transaction, according to Rubinson). Relational Technology redid the architecture on its DBMS this past year, says Sprinzer, and the company will be releasing products over the next two years that will let users "write an application once on VMS and then access it transparently on Unix." Oracle's Ken Jacobs said his company wants to "make GUIs [graphical user interfaces] invisible. We're working very hard to make a product look like Presentation Manager, the Mac interface, or Open Look." Expect announcements "very soon," he said, that point toward the "integration of data dictionaries and computer-aided software engineering tools into one thing."

Most vendors and consultants agree that the database environment isn't all that mixed at the top. IBM has the mainframe world sewn up with DB2. "Anybody who'd compete against DB2 is nuts," said one panelist at DB/Expo.

Superconductivity Still a Cool Proposition

Superconductor research in the past year has advanced incrementally, but researchers have made no major breakthroughs, according to the evidence at the second annual International Superconductor Applications Convention, held recently in San Francisco.

Although one young company called Magnetic Power, Inc. (Sebastopol, CA), claimed to have developed a bismuth thin film with superconducting properties at room temperature, the claim has not been verified or reproduced in other laboratories. Another researcher, Dr. Brian Ahern of the Rome Air Development Center at Hanscom Air Force Base in Massachusetts, claimed to be close to verifying room-temperature superconductivity using titanium boride. However, the evidence was still preliminary and has not been reproduced.

Conference keynote speaker Dr. Simon Foner, chief scientist at the Francis Bitter National Magnet Laboratory, warned against the "overhype" of the media regarding superconductivity breakthroughs and called for more "truth in advertising." Foner said that high-temperature (77° Kelvin) superconductive materials still are not practical for most commercial applications. But Foner also cautioned against the pessimistic fears that the U.S. "will lose to Japan" in the race to produce commercial superconductivity applications.

Most of the research presented at the conference is still focused on a transition temperature range of 4° to 120° Kelvin. The transition temperature is the maximum at which the material exhibits the superconducting properties of virtually zero resistance and high magnetic shielding. Both U.S. and Japanese researchers are working on developing new materials and production methods for superconductivity applications.

A major problem involves increasing the thermal and structural stability of very thin films used in superconductivity applications. Because of the sensitivity to temperature and the large energy density required in superconductive materials, thermal stability and high yield strength are crucial properties. Some of the research going on at companies like General Electric and IBM involves developing high-strength substrates, such as graphite, on which the superconducting film is mounted.

According to some sources, financiers are keeping a cool eye on the super-

continued

NANOBYTES

XRAYZ80 package includes a compiler, an assembler, a software simulator, and a debugger. In addition to the vendor's own simulator package, the debugger supports in-circuit emulators from Hewlett-Packard, Applied Microsystems, and ZAX. The IBM PC version starts at $3500; the solo debugger starts at $1750.

• **NEC** (Tokyo) plans to start offering samples of a **33-MHz μPD70632 MPU** this fall and a 40-MHz model next year. A 45-MHz version has been tested, and the company hopes to develop 50- and 60-MHz versions next.

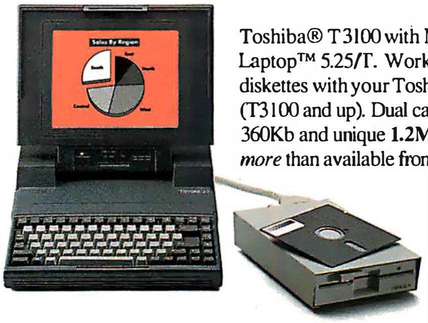
• Guides to Words and Street Corners: **Highlighted Data** (Washington, DC) has put out two of the more **helpful CD-ROM products** we've seen yet. The first is a **version of Webster's Ninth New Collegiate Dictionary**, which not only includes all the text and diagrams in the hard-copy version, but **also talks.** The disk contains recorded pronunciations of each word in the dictionary. The second CD-ROM can generate almost any street map of the U.S., the vendor says. The company claims that the **Electronic Map Cabinet** disk includes every street corner in the country. Both disks cost $200.

• **Farallon Computing** (Berkeley, CA) plans to extend its reach into high-speed Ethernet systems, company officials say. Due for a midyear release, Farallon's **EtherTalk** is an implementation of Ethernet protocols for AppleTalk networks. Like Local-

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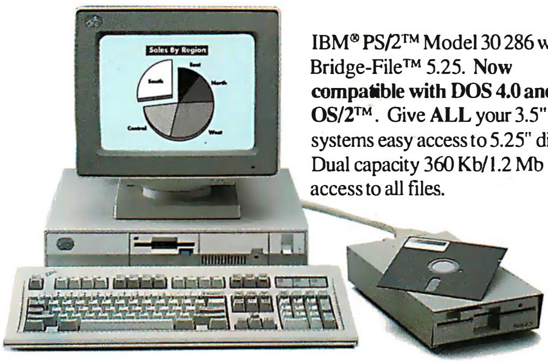
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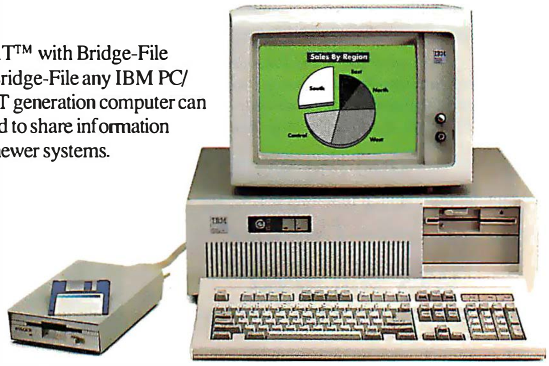
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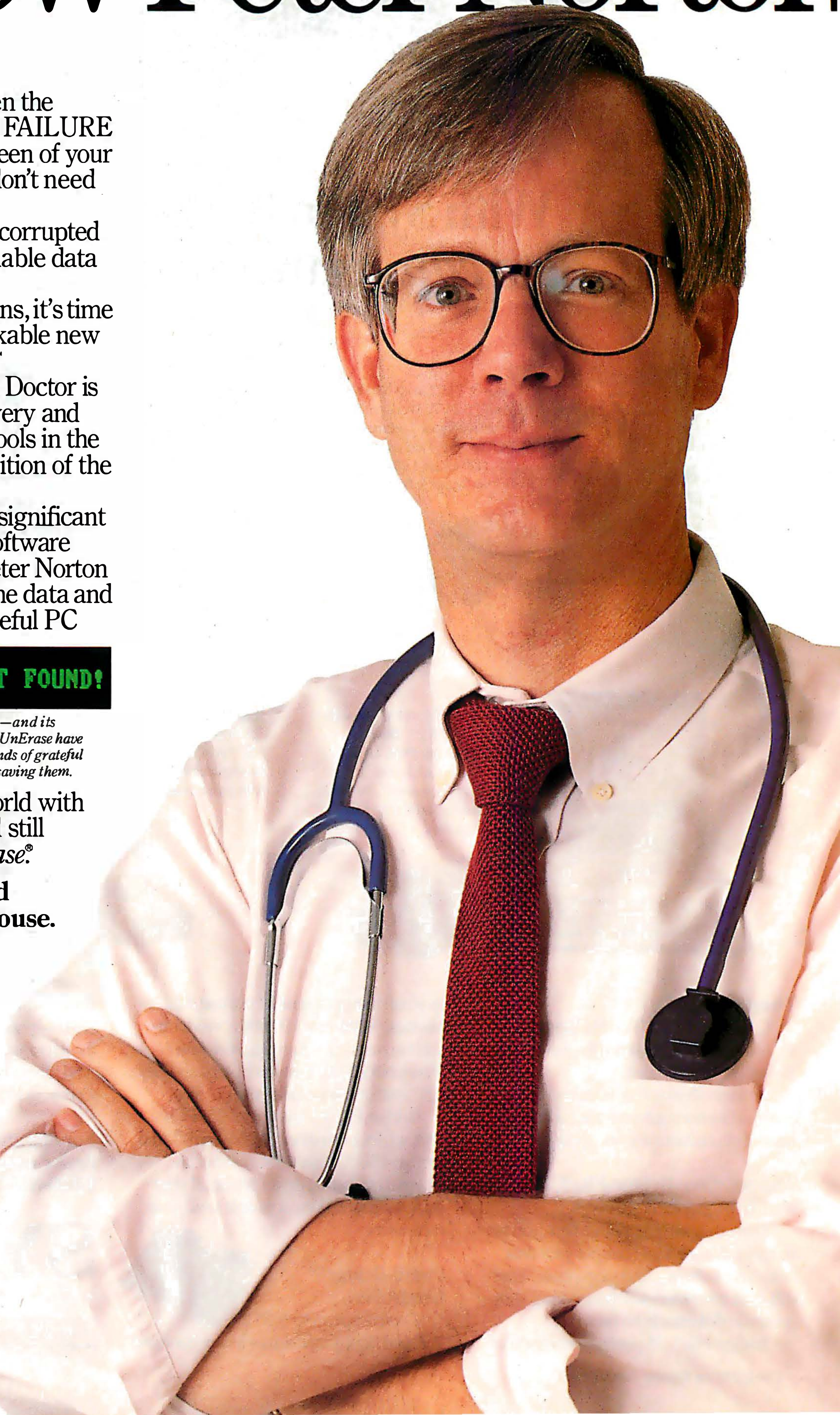
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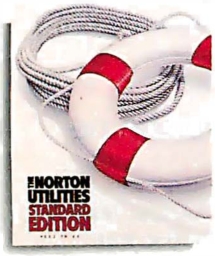
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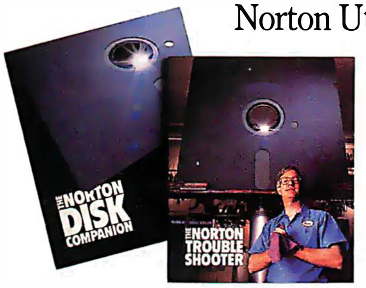
Frankly, the Norton Disk Doctor and the Norton Troubleshooter are worth the price of the new Advanced Edition all by themselves.

But, of course, they aren't by themselves.

They're accompanied by a wish list of features, functions and enhancements sufficient to satisfy the yearnings of all those people who've been politely writing and calling to request them.

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Like *Speed Disk,* the world's most powerful disk tuning tool, which features four user-selectable optimization methods and doesn't lose your data if you lose power.



The Norton Disk Companion is included, free, with both the Standard and Advanced Editions. The Norton Troubleshooter is yours with the Advanced Edition.

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Our user interface, which *InfoWorld* said made the Utilities "as easy to use as possible," now comes with pop-up windows and dialog boxes.

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Which means they'll erase your files so thoroughly not even Peter Norton can find them.

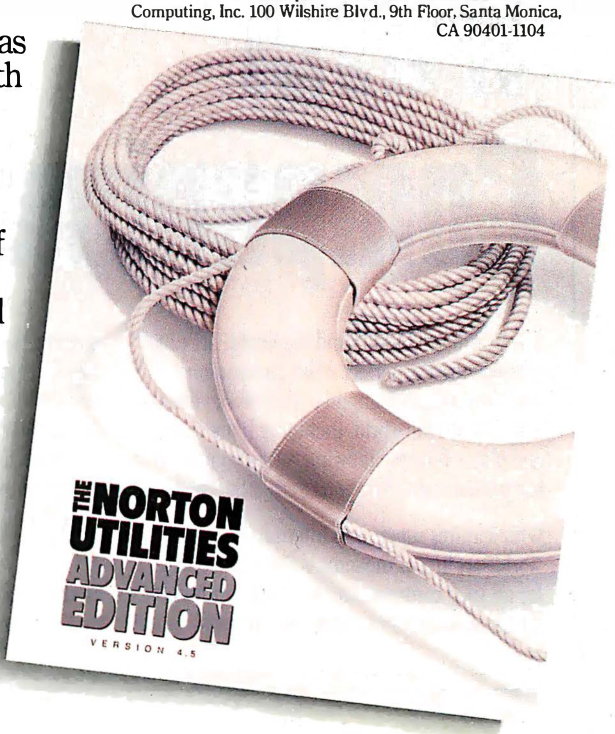
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COMPUTING

All Utilities now support large hard disks under DOS 4.0, COMPAQ DOS 3.31, and the PC-MOS/386 multi-tasking operating system. Designed for the IBM®PS/2®and PC families and 100% compatibles. © 1988 Peter Norton Computing, Inc. 100 Wilshire Blvd., 9th Floor, Santa Monica, CA 90401-1104



Circle 322 on Reader Service Card (DEALERS: 323)

NANOBYTES

Talk, EtherTalk will use the twisted-pair wiring of telephone lines. Farallon plans to provide all the "in-building plumbing" for EtherTalk, said company president Reese Jones, including connectors that attach to a standard Ethernet AUI port ("all IEEE 802.3 devices") and a StarController to build and control topology. PhoneNET with EtherTalk will run about $1000 per machine, Jones said.

• **Publishing with Iris:** Full Color Computing (Danbury, CT) now has versions of its **Full Color Publisher** desktop-publishing-and-more program for Silicon Graphics's three-dimensional

continued

conductor industry. Although the government and some venture capitalists are willing to take the risk of funding something so abstract, many would-be backers think commercial development is too far away. In a survey by Coopers & Lybrand's High Technology Industries Group in Boston, 60 percent of the capitalists questioned said an adequate return on investment would not be possible in the 10-year span of a limited partnership; 29 percent said the technological risk is too high.

CEBus Chip Provides Brains for Jetsonesque Smarthome

You're on the couch, watching television. The turkey is done roasting, so, using your TV remote control, you shut off the oven. Then you realize how cold it is inside the house, so, using the same remote control, you close the curtains and turn up the thermostat. Then it's back to Big Time Wrestling.

That's part of the promise of "home automation" as promoted by the Electronic Industries Association. The EIA wants the backbone of Jetsonesque abodes to be the Consumer Electronic Bus (CEBus), proposed as a standard by which home appliances can communicate with each other. Some heavyweights of home electronics demonstrated this LAN for dishwashers, VCRs, microwave ovens, and entertainment systems at the Winter Consumer Electronics Show in Las Vegas.

The CEBus "Smarthome" exhibit at CES featured 17 appliances, including a Sony television, an RCA VCR, and a Johnson Controls thermostat (those companies are all EIA members). At the heart, or brain, of the demonstration was AISI Research's "Spirit" technology, the first implementation of the CEBus architecture in a silicon chip.

CEBus is a set of specifications for encoding and transmitting information over almost any medium, including twisted-pair wires, coaxial cable, infrared signals, radio waves, and fiber optics. But the focus of AISI and the EIA is to use a house's existing AC power

continued

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NANOBYTES

workstations, including the mighty Personal Iris. Full Color Publisher goes beyond page layout; it also has tools for painting, retouching photos, and manipulating images. The package that runs on SG's Personal Iris sells for $8995.

• **How do you pronounce "loquitur"?** The Franklin Language Master-4000 can tell you. It's a **hand-held electronic talking dictionary** capable of speaking 83,000 words. You simply type in the word you'd like pronounced. The product, by **Berkeley Speech Technology** (Berkeley, CA) and **Franklin Computer** (Mt. Holly, NJ), uses

continued

lines for transmitting data, since they're found in practically every house today. Not only would you be able to program appliances from, say, your cellular car phone, but your appliances could also communicate with each other. With CEBus, manufacturers could create a remote control that handles any number of appliances.

AISI Research admits that the technology hasn't been perfected. Most home power wiring isn't designed to carry data, so there's a tendency for home systems to have "white noise"—background interference caused by the system.

The Spirit chip evolved from the AISI "brick," a device containing a microprocessor coupled with analog circuitry to provide full implementation of CEBus. The Spirit chip incorporates all the functions of the much larger brick, while improving performance and signal quality, according to AISI Research. The company, based in Vancouver, BC, is marketing the chips for about $5.

Insignia Sees Unix Market as Biggest Opportunity for DOS Emulator

Although Insignia Solutions introduced a new version of its SoftPC MS-DOS emulation program for the Mac II at January's MacWorld Expo, the company's bigger target market for SoftPC is the Unix environment. Because of the virtual memory capabilities of Unix-based machines, the emulator can access a much larger memory space than it can on the Macintosh, and therefore it can perform better and run MS-DOS programs using EGA and VGA graphics standards, says Insignia CEO Nick Samuel.

The whole trick to the SoftPC emulation technology is translating the MS-DOS Intel-based instruction to a set of instructions executable by the host machine's processor, which can be a Motorola, as in the case of the Mac, or other RISC processors supported on various Unix platforms. However, the translation is not one-for-one. On the Macin-

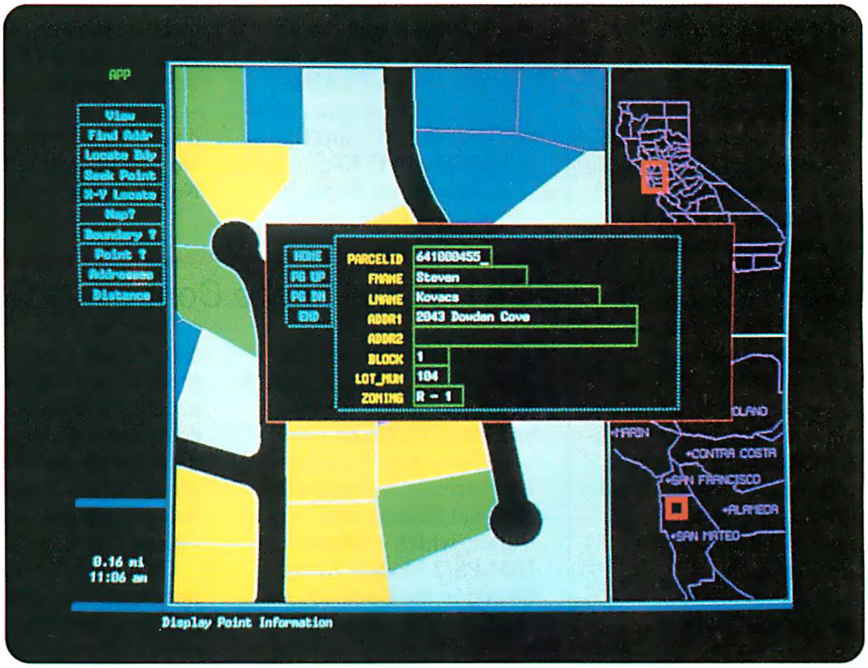
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Advertisement

MAPPLICATIONS ■ Sean O'Sullivan

UNDERSTANDING DESKTOP MAPPING

Recent developments by MapInfo in linking graphics with traditional database information results in new ways to visualize data



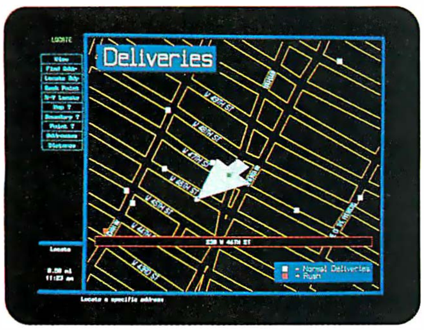
Database Information Merged With Maps *MapInfo's desktop mapping package is the only software designed to directly tie dBASE files with maps. The parcels shown here were automatically shaded based on the data about each. A window is displayed that reveals the actual data behind a particular parcel.*

Rarely has a new software technology burst into the marketplace with the excitement and high potential of desktop mapping. More than 100 specific applications for desktop mapping technology have already emerged, and current estimates suggest that over 80 percent of PC users could make immediate use of this new tool.

Desktop mapping has little to do with the *making* of maps — the job of cartographers. Rather, it involves the *use* of maps to get more meaning and knowledge out of databases — particularly if they have some type of locational field, such as a street name and number, city, ZIP code, county or state.

A lot of software products out there are putting themselves (or are being put) into the desktop mapping category, which runs the spectrum of functionality, ease of use, and price.

One product—MapInfo, from MapInfo Corp.—has emerged in the past year, offering the performance and capabilities of high end packages at a price and ease of use that competes with the low end.



Find Addresses *MapInfo Corp.'s street maps come with every address already in place, accurate to the correct block and side of street. Simply type an address and MapInfo locates it for you. Or, automatically plot existing data on the map for "what-if" analyses.*

On the low end, there are products that sell for $350 to $1000 and which are just specialized graphics programs. These programs allow you to take a map, such as one of the United States, decide what colors each state should be, and then overlay text for titles, legends, and captions. However, they cannot interact directly with your database, and do not have the intelligence to find specific addresses at the street map level.

On the high end, there are expensive software products that are typically called Geographic Information Systems (GIS). These products will let you combine your databases with maps in an interactive fashion. Even when converted for use on a PC, however, they are still expensive, starting at $5,000 for the software alone.

But for $750 you can buy the powerful MapInfo engine, which reads your dBASE files and lets them interact with an incredible range of computer maps. The maps, including street maps for most metropolitan areas, county maps, state maps, and so forth, are available separately from MapInfo Corp.

Already, thousands of people across the nation are using MapInfo to gain more knowledge from their databases. Synthes Corp. is using MapInfo to do new market research in Paoli, PA. The Syracuse, NY police department is using MapInfo to visually compile crime statistics. And, in San Francisco, MapInfo is being used to compare locations of AIDS cases with educational outreach efforts.

> ***"One product—MapInfo, from MapInfo Corp.—has emerged in the past year, offering the performance and capabilities of high end packages at a price and ease of use that competes with the low end."***

MapInfo Corp. has established a special toll free hot line to answer your questions about this exciting new technology. For more information, call 1-800-FASTMAP or 518-274-8673, or write to them at 200 Broadway, Troy, NY 12180.

NANOBYTES

Berkeley's Bestspeech text-to-speech (T-T-S) conversion technology, which previously has been available only at high prices for personal computers and mainframes. Speech quality and pronunciation accuracy are on par with Berkeley Speech Technology's most expensive speech-to-text systems, the company claims. The Franklin Language Master-4000 retails for about $300. Berkeley Speech Technology has also licensed Bestspeech T-T-S to Hewlett-Packard and Personal Data Systems. Possible future applications, besides talking dictionaries, include talking translators, word processors, and talking toys with mega-vocabularies.

• ROMmed DOS: **Award Software** (Los Gatos, CA) has started shipping a **ROMmed version of Digital Research's DR DOS**, an MS-DOS 3.3-compatible operating system. The **Award ROS** is available in a "hard" version on four 64K-byte chips (on a $250 plug-in board) or as modules of object code that can be licensed to system developers. Developers can pick from modules that perform parts of DOS and then burn those modules into ROM chips to be installed on the system baseboard. For diskless workstations and smart terminals, Award claims ROS will allow faster, more intelligent, and more flexible designs. "With key parts of the OS at the workstation, you don't have to go back to the server to get every command," said Award president Rene Vishney.

tosh, for example, SoftPC executes from 8 to 10 native Motorola 68000 instructions for every DOS instruction. This ratio determines the performance of the DOS emulation. On a 68020, DOS programs running under SoftPC perform approximately equivalently to an Intel 8088-based personal computer. On a 33-MHz 68030-based machine, Samuel said, SoftPC runs like a 6-MHz IBM PC AT.

At MacWorld Expo, Insignia had SoftPC with EGA support running on Intergraph workstations with the Fairchild Clipper processor. A version without EGA support is available on HP 68000-based workstations. Insignia plans to have this high-performance version running soon on other Unix systems and on DEC VAX minicomputers.

Samuel says Insignia has discussed with NeXT a possible port of SoftPC to the NeXT computer. But he said it is "premature" to talk about these discussions. It requires a major investment to port SoftPC to a new hardware platform—in the "high six figures," he said.

Insignia Solutions also has a SoftPC version ready for Apple's A/UX version of Unix, but, according to Samuel, there has been very little demand for it.

Contact: Insignia Solutions, 787 Lucerne Dr., Sunnyvale, CA 94086, (408) 522-7600.

C&T's New Cache Controllers Compete with Intel's

Chips & Technologies' new set of cache controller chips suitable for 20- and 25-MHz 80386-based systems is entering a market currently dominated by the Intel 82385 cache controller, which is used in the IBM PS/2 Models 70 and 80 and in the Compaq Deskpro 386. The company hopes to compete with the Intel device by offering a unique design that integrates memory and cache control on the same chip. This integrated chip eliminates the need for a discrete DRAM controller, which is required with the Intel chip, according to Chips & Technologies product manager Nelson Chan.

Chan said the company's integrated design also minimizes cache "misses" and thus makes possible better performance than the Intel 82385. Chips & Technologies claims that its cache controllers (called the 82C307 and the 82C327) will result in OEM system cost savings of up to $94 in comparison to the cost of implementing the Intel cache controller design.

Possible customers for the Chips cache controllers include Zenith, Tandy, Texas Instruments, and Dell Computer, though none of these companies have officially confirmed that they will use the controllers.

Graphics Hardware Designers Like Mac SE/30's Slot

Although the Mac SE/30's 030 Direct Slot is incompatible with the NuBus and the standard Macintosh SE expansion slot, designers of graphics equipment are very pleased with it. Why? The 030 slot offers faster video performance than the NuBus, since there's no need to worry about bus arbitration or synchronizing with the 10-MHz clock speed of the NuBus. In interviews with Microbytes Daily at MacWorld Expo, designers agreed that the 030 Direct Slot is a nice piece of engineering.

SuperMac quickly introduced its Spectrum/8 Series II card right after the official debut of the SE/30. This 8-bit color display card supports displays of up to 1024 by 896 pixels with 256 colors. Its Virtual Desktop feature lets you work with a larger desktop than the actual size of the monitor. (The actual size depends on the graphics mode; in black and white, the Virtual Desktop is 4096 by 1792 pixels.)

E-Machines has introduced a 21-inch monochrome display for the Mac SE/30. The Big Picture Z21 SE/30 has a two-million-pixel video memory and can support screen sizes up to 2048 by 1024 pixels.

RasterOps doesn't have anything for the Mac SE/30 yet, but vice president David Smith says it will offer all its color boards and a version of its new accelerator board on the Mac SE/30.

TECHNOLOGY NEWS WANTED. *The news staff at BYTE is interested in hearing about new technological and scientific developments that might have an impact on microcomputers and the people who use them. If you know of advances or projects relevant to microcomputing, please contact the Microbytes staff at (603) 924-9281, send mail on BIX to Microbytes, or write to us at One Phoenix Mill Lane, Peterborough, NH 03458. An electronic version of Microbytes, which offers a wider variety of computer-related news on a daily basis, is available on BIX.*

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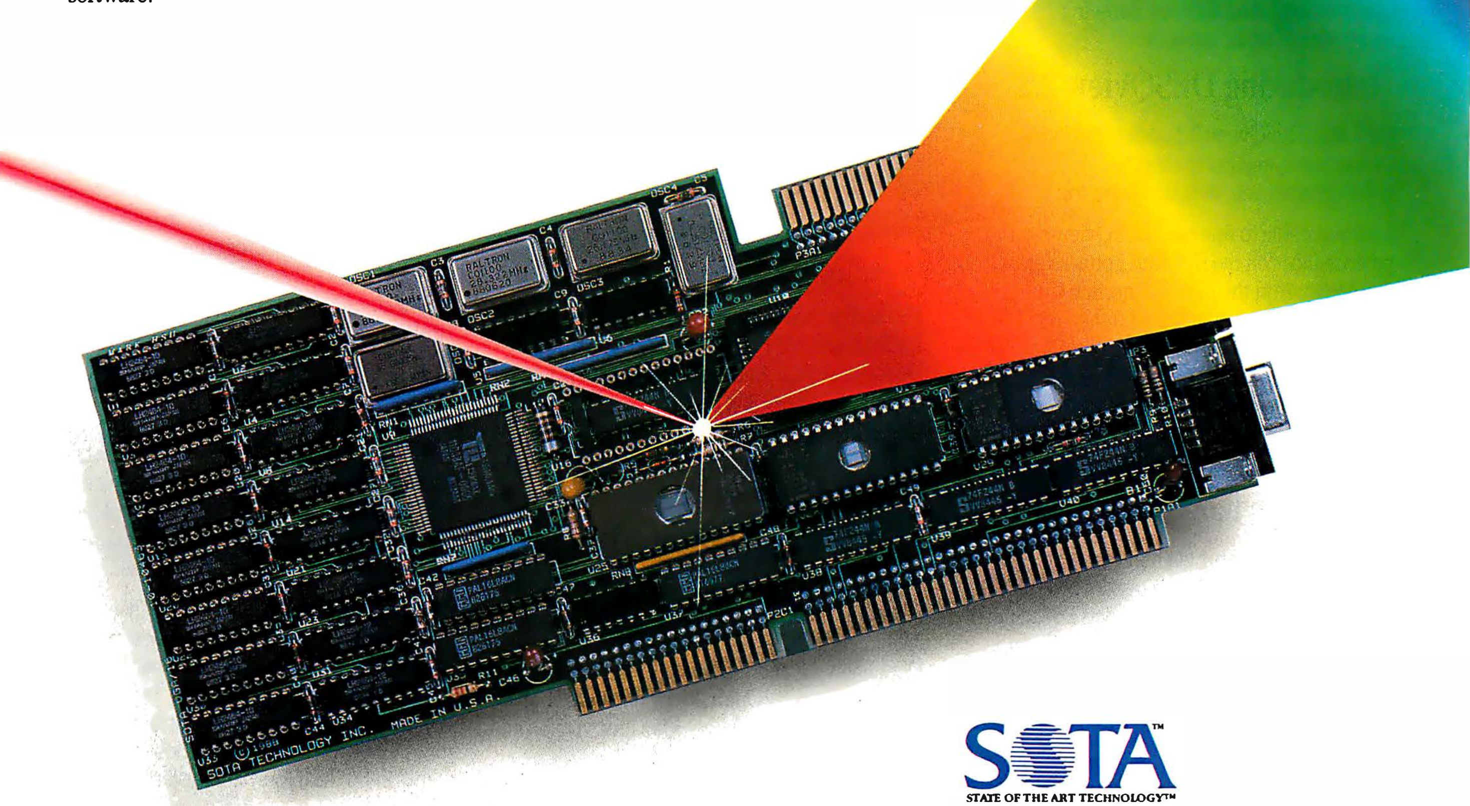
The SOTAVGA / 16 is 100 % VGA hardware compatible and runs current programs such as Windows 386 and OS / 2 flawlessly. It is also hardware compatible down to register level with all pre-VGA standards such as EGA, CGA, MDA and Hercules. This means that virtually all existing software will run with the SOTA VGA / 16 — and it insures compatibility with future software.

SOTAVGA / 16 has two output connectors for full analog and digital monitor support — not just analog, as some manufacturers offer. And, since many of today's programs require a mouse, SOTA built this option right on the board. No longer do you have to compromise an extra slot or sacrifice one of your COM ports to install a mouse. Simply plug it into SOTAVGA / 16.

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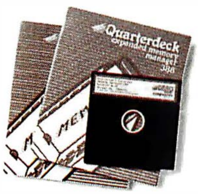
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The DESQview API Debugger is an interactive tool enabling the API programmer to trace and single step through API calls from several concurrently running DESQview-specific programs. Trace information is reported symbolically along with the program counter, registers, and stack at the time of the call. Trace conditions can be specified so that only calls of interest are reported.

API Panel Designer

This interactive tool helps you design windows, menus, help screens, error messages, and forms. It includes an editor that lets you construct an image of your panel using simple commands to enter, edit, copy, and move text, as well as draw lines and boxes. You can then define the characteristics of the window that will contain the panel, such as its position, size, and title. Finally, you can specify the locations and types of fields in the panel.

The Panel Designer automatically generates all the DESQview API data streams necessary to display and take input from your panel. These data streams may be grouped into panel libraries and stored on disk or as part of your program.

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LETTERS

and Ask BYTE

PC Power

Congratulations on the much-needed article "PC Power" Parts 1 and 2 by Mark Waller (October and November 1988). There is altogether too much misinformation being cast about by those who pretend to know. Specifications that may sound impressive in a peddling contest often have little to do with the real issues. The problem is confounded by oft-quoted mavens and other self-proclaimed pundits who still speak from the "landmark" studies of the seventies that have long since been determined to be invalid. Some seem to think, however, that it is enough just to know studies were done.

Waller describes many of the shortcomings of surge suppressors and ferroresonant transformers with respect to the needs of modern electronic loads. All I would add to his already good comments is that not only are these approaches not as good as alternatives, but they are actually harmful when misapplied. This point could have been made stronger, I think. All in all, though, Waller's article should go a long way toward broadening the respect for the subject, if not the understanding.

Having said all that, there are two technical points that should be corrected or clarified. In Part 1 on page 280, under the heading "A Better Solution," the text reads, ". . . a couple of capacitors and a MOV across the secondary. . . ." In actuality, the clamping circuit (MOV or otherwise) belongs on the primary side of the transformer.

A second point concerns Waller's suggestion in Part 2 of a marriage between a true power-line conditioner and a standby power system. This is fine. But the recommendation to put the transformer-based power conditioner on the output of an SPS needs to include one important caveat—you shouldn't drive a transformer with a square wave, or even a pseudosquare wave.

AC power is a very complex phenomenon. But, like music, it has been made so readily available that nearly everyone takes it for granted.

David Fencl
Oneac Corp.
Libertyville, IL

I do not agree that the MOV and filter must be on the primary side of the transformer. Although Oneac puts them there, other manufacturers put them on the secondary side. I'm not sure it makes much difference except that the components tend to be protected by the transformer if they are on the secondary side.

I did not raise the issue of reliability because establishing it from one product to the next is extremely difficult, and I thought a discussion of it was beyond the scope of the article. Implicitly we all want the most reliable product. I'm not sure I understand if you are referring to components, design, or one manufacturer against another.

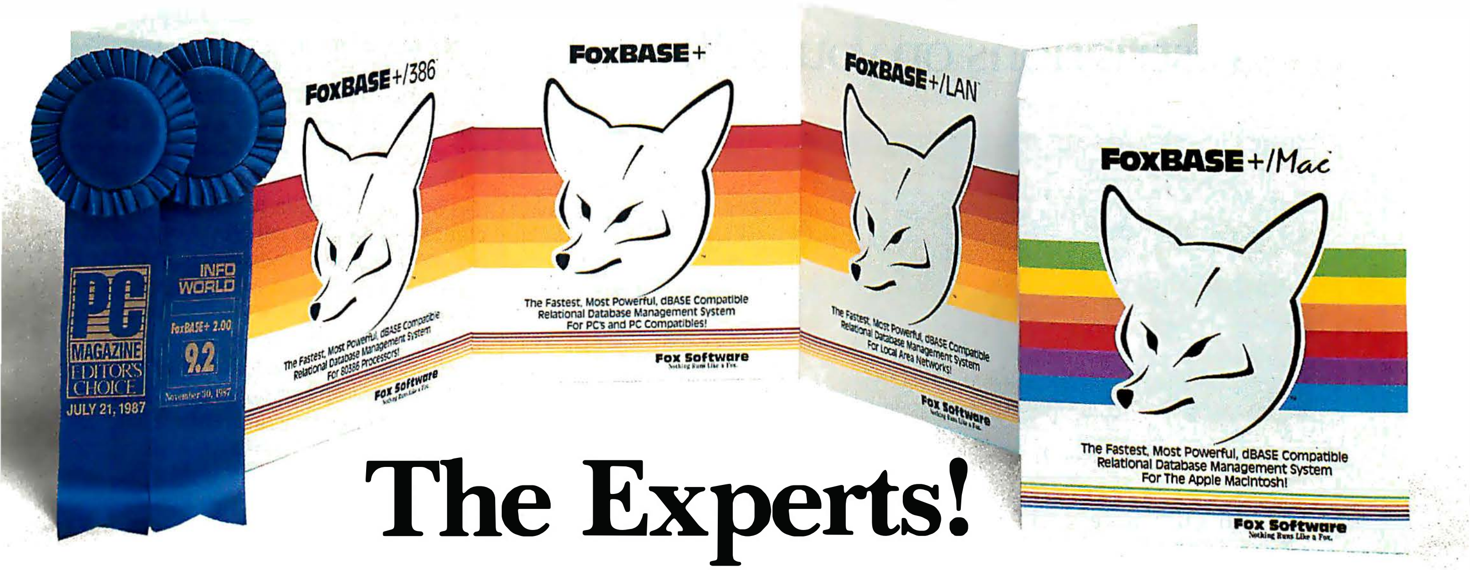
I do not agree with you that "you shouldn't drive a transformer with a square wave, or even a pseudosquare wave." I know of no compelling reason for this except that if the filter elements are on the primary side of the transformer, they might heat up and fail handling the noise and harmonics from the wave shape, remembering that this occurs only when utility power fails. This further implies that the personal computer can handle this better than a transformer. Again, I don't agree. The whole point of the article was to urge people to buy products with a clean sine wave output so that these concerns are eliminated. The isolation transformer should always be the last line of defense—the closer to the computer, the better.—Mark Waller

WE WANT TO HEAR FROM YOU. *Please double-space your letter on one side of the page and include your name and address. We can print listings and tables along with a letter if they are short and legible. Address correspondence to Letters Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*

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Ethical Medicine

Many people are alarmed about computer viruses. The final solution to these viruses involves more than technology.

Writing a program that disrupts and destroys computer activity is an expression of immaturity, economic pressure, or the fear of military systems. Usually, the motivation is to magnify one's ego or to get revenge on an employer. Sabotaging a competitor's products and mucking the military are distinct possibilities as well.

The final solution to this sickness includes a vision that can excite our imaginations along more positive paths. It is a vision of making all human knowledge immediately accessible to any person, anywhere on planet earth. It is a vision of enabling each individual to live to the fullest of his or her potential. It is a vision of well-being and wholeness in which a healthy information system is an essential part.

John Baltzer
St. Louis, MO

Your Check Is in the Mail

Although I am not new to computers, I have been away from them for eight years due to my career studies. My love for computers began about 14 years ago, when the Z80 chip, CP/M, and BASIC were the ruling clan of the microcomputer world.

This world has changed for the better. Now we have the Intel 80386 chip, OS/2, and C, the ruling clan of this modern era. Things that we could only dream of then are second nature for Those Software Packages and Their Magnificent Computing Machines.

Today's computer world could have been very intimidating for a neophyte like me. But not anymore, thanks to BYTE and its knowledgeable staff. Thanks for giving me the best source of information month after month to keep my long-enduring love for those amazing silicon wonders strong and growing.

Carlos A. Arche
Caguas, Puerto Rico

We Are Not Amused

So the Russians are coming, are they? (Editorial, October 1988). After reading editor in chief Fred Langa's report about the software demonstrated by the Soviet delegation, we were anxious to download the programs from BYTEnet (a process that took a very long time at 1200 bps—please note that the price of 2400-bps modems in your advertisements has come down considerably) and run them.

continued

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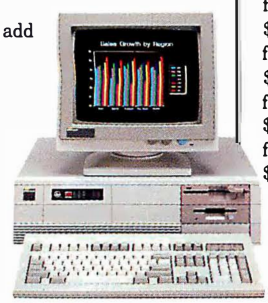
Business Computer Digest

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Personal Computing Magazine

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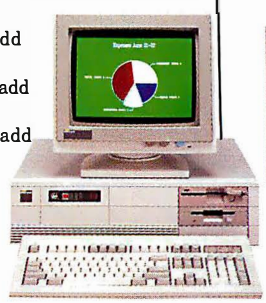
InfoWorld Magazine

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Power Meter MIPS Version 1.2. The Database Group.

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While the software was entertaining and unusual, we found three areas worthy of comment.

The first thing we noticed was the flashy interface complete with startling sound effects. In fact, the sounds bore an uncanny resemblance to the sounds that can be heard emanating from the computer room when our sons are down there playing.

The authors of the software seem to have made the same mistake that a lot of other authors make—that is, to confuse a flashy interface with a user-friendly interface.

While the screen layout was very good and the exploding windows fit in very well, the actual text was anything but user-friendly, and the sound effects were distracting, even annoying, in this context. (Besides, we kept wondering whether they were lifted directly from the code of some commercially available games.)

The second area we noted was the thrust of the programs themselves. We should be flattered that the Soviets think that the general intellectual level of the American public is so high, but the truth is that the programs will have limited appeal in the general market, aside from the ivory-tower crowd.

Finally, we were interested in the Soviets' use of the English language. We are impressed with their command of English but surprised that they didn't at least go the additional step of hiring someone to check spelling, syntax, and idioms. While Americans put up with manuals that are written in some oriental language and then translated into English because the hardware works, when the use of the product itself is impaired because of the language problem, we doubt Americans will be so tolerant.

Overall, we give the Soviets a good grade for a first effort at competing in the U.S. market, but we still don't think they're here yet. We also doubt their claim that, "Without any exaggeration, the NeMo-Tec can be considered as an example of the software technology of the next decade—or even of the next century."

Chris Bidstrup
Idaho Falls, ID
Kent Howcroft
American Fork, UT

Intuition and Theory

I would like to add to R. N. Bracewell's terse dismissal (Letters, November 1988) of the point made in John C. Polasek's letter (August 1988). Polasek's point is born of good intuition and has also been put forward by some of my colleagues in the past. This being the case, I thought it might be useful to offer what might constitute a reconciliation of intuition with theory.

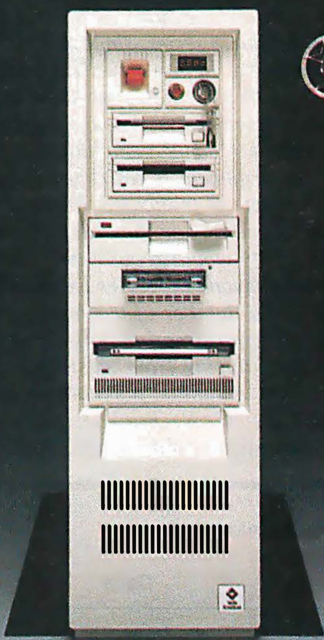
On the surface it would appear, from a functional analysis point of view, that the function set $(\cos(wt)+\sin(wt))$ does not form a complete basis set, even for real functions. In other words, the null space of the Hartley mapping is by no means empty, and while it is true that neither of the basis functions represented by the complex Fourier kernel is orthogonal to the "cas" kernel, many functions formed by linear combinations of them seem to be. For example, one might ask, What is the Hartley transform of the set $(\cos(ut)-\sin(ut))$, which is orthogonal to the "cas" kernel. . . or is it?

This valid question, on further examination, leads to a very simple reconciliation: The Hartley transform and its inverse are mapped into ± frequency and

continued

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± time. The "negative frequency" component of the transform does contain the information represented by the basis set $(\cos(ut) - \sin(ut))$. That is, $(\cos(-wt) + \sin(-wt))$ is identical to $(\cos(wt) - \sin(wt))$. Thus, the seemingly missing, orthogonal component of the Hartley kernel is represented by the mapping into a "negative frequency" range, with the phase information preserved in the relative positive and negative components at each frequency.

Though, in this case, you find an intuitive oversight, I think it illustrates the importance of submitting a formal proof to the acid test of good scientific intuition and resolving any apparent contradictions. All too often, only the reverse is done.

Ron G. Walters
Cleveland, OH

No Coprocessor

In "Floating-Point without a Coprocessor, Part 2" (October 1988), Rick Grehan says to use Taylor-series expansions for the implementation of the trigonometric functions. I disagree. Taylor functions have terrible convergence when high decimal-point accuracy is desired. Instead, I recommend the following approximation for the sine function (x is in radians):

$$\mathrm{Sin}(x \times \pi/2) = c_1x + c_2x^3 + c_3x^5 + c_4x^7 + c_5x^9$$

where

$c_1 = +\ 1.5707\ 9631\ 847$
$c_2 = -\ 0.6459\ 6371\ 106$
$c_3 = \quad 0.0796\ 8967\ 928$
$c_4 = -\ 0.0046\ 7376\ 557$
$c_5 = +\ 0.0001\ 5148\ 419$

This approximation has an error of ±0.0000 0000 5, which translates into eight-decimal-place accuracy. I coded this function on my Apple Lisa and obtained the comparison ($f(x)$ is the approximation) in table 1.

For a very good list of function approximations, I recommend *Approximations for Digital Computers* by Cecil Hastings Jr. (Princeton University Press, 1955).

David Craig
Wichita, KS

You are correct in that the Taylor-series expansion I gave (actually, it should be called a McLaurin series, since that's the term used for a Taylor series expanded around x = 0*) for sine*(x) *isn't the best for digital computer use. Though it might be passable for some computations as long as the argument is restricted to the first quadrant, a truncated McLaurin series with accuracy on the order of your example's 10^{-8} would require two additional terms beyond the series I showed.*

There are a number of techniques for deriving an approximating polynomial's coefficients, ranging from least-squares regression to minimax polynomial approximations. F. R. Ruckdeschel, in BASIC Scientific Subroutines, Vol. 1 *(BYTE Books, McGraw-Hill, 1981) presents a least-squares analysis program and uses it to generate an approximating polynomial for sine*(x) *good to an accuracy of about 10^{-14}. The results are shown in table 2. Keep in mind that, when working with series approximations like this, you should construct your algorithm so that the higher-order terms are accumulated into the result first so that you avoid errors generated by adding small numbers to large numbers.*

Also, I don't think your definition of radians is quite right, since 1 radian is 57° and sine(π/2 radians) = 1.0.

—Rick Grehan

Table 1: *Coefficients for sine*(x) *accurate to eight decimal places.*

x	f(x)	Sin(x × π/2)	Delta
0.000	0.00000000000	0.00000000000	0.000e+ 0
0.200	0.30901699496	0.30901699437	−5.813e−10
0.400	0.58778525441	0.58778525229	−2.1173− 9
0.600	0.80901699004	0.80901699437	4.333e− 9
0.800	0.95105652100	0.95105651630	−4.707e− 9
1.000	1.00000000531	1.00000000000	−5.310e− 9

Table 2: *Power series approximation for sine*(x) *accurate to approximately 10^{-14} over the range $-\pi/2 <= x <= \pi/2$.*

Coefficient	Value
C_1	−0.1666666666671334
C_2	0.00833333333809067
C_3	−0.000198412715551283
C_4	0.0000027557589759762
C_5	−0.0000000250705987620 7
C_6	0.000000000164105986683

Impressive Workstation

Thanks for an interesting look at the NeXT workstation. The system is impressive in all respects except for the slow access time of its primary storage device. I wonder whether common sense was overridden by the call of the wild, especially since Unix performance is directly related to disk performance.

I don't wish to belittle the importance of the new optical drive. The removable high-capacity read/write optical disk is truly revolutionary, particularly in its implications for data backup and security. A drive failure means that you could swap out the bad hardware, slide in the backup media, and boot back up, drastically cutting downtime. Sensitive data can now be physically removed from the system (not just erased) and locked up at night. The 60-megabyte streaming tape drive would no longer be the standard backup device since the backup could be from disk to disk. Sounds great.

I hope NeXT decides to give the marketplace a break and offer a more conventional high-performance (5-millisecond?) hard disk drive as the primary drive. Nowhere is it written that you cannot be radical and open-minded at the same time.

Peter Matsunaga
Aiea, Hawaii

Where to NeXT?

Thank you for your complete report on NeXT's cube computer ("The NeXT Computer" by Tom Thompson and Nick Baran, November 1988). I am a computer engineer at the University of Oklahoma, and the machine sounded perfect for me, so I immediately set out to buy one.

I asked the people at our purchasing office about the machine, and they said they had not been contacted by NeXT and would not carry the company's ma-

continued

chines unless approached. I could understand that, so I called NeXT to get the ball rolling. When I finally got a representative, I told her that I was interested in purchasing one of NeXT's machines but that the university's purchasing office had not yet been contacted. To my dismay, the representative told me that the university must contact NeXT to start any student purchases. That was my first catch-22.

NeXT's purpose was to sell to universities and major research institutions. Oklahoma University is a major university, and I still can't get a NeXT computer. I asked NeXT if there was any other way I could purchase its machine. I was told that I could try purchasing one from another university. Great! Except the person I spoke with wouldn't tell me the name of any university that was selling NeXT machines. Another catch-22.

I started out really wanting this computer. It still is an incredible piece of hardware, but until NeXT changes its policies, I would not recommend anyone buying one.

Scott Fields
Norman, OK

One Year Later

In the April 1988 issue of BYTE, you published a letter of mine suggesting the use of the work by Michael F. Barnsley and Alan D. Sloan ("A Better Way to Compress Images," January 1988) for the compression of databases.

The method did indeed compress the databases about 100 to 1 in most cases. However, Barnsley and Sloan's method is lousy, and as a result the data when decompressed was not exactly the same as the data before decompression. However, the method did discover underlying patterns in the data.

The discovery of these patterns allowed the development of a better access system to the data, sometimes increasing access to connected pieces of data by 50 to 1. More important, it allowed the discovery of connections within the data structure that were not thought to exist.

The ability to discover connections within a database does have interesting implications for expert systems and rational database structures.

Robert McLaughlin
Arlington, VA

Buy the Book

I greatly appreciated Jerry Pournelle's generous comments in his December 1988 Computing at Chaos Manor about our new book, *LaserJet Unlimited, Edition II*. Unfortunately, although the name of the publisher was listed, no city or mailing address was included. For those readers who would like to buy a copy, it's available for $24.95 plus $3 shipping from Peachpit Press, 1085 Keith Ave., Berkeley, CA 94708, (415) 527-8555.

Ted Nace
Berkeley, CA

An Orphan Variable

While discussing the creation of contour plots in the computational statistics class I'm teaching this semester, my class and I tried to duplicate figure 1a in Paul D. Bourke's June 1987 article entitled "A Contouring Subroutine." The article claims that the figure is a contour map of the function

$$f(x,y) = \sin((x^2+y^2)^{1/2}) + \frac{.5}{\sqrt{(x+3.05)^2+y^2}}, \quad -2\pi \leq x,y \leq 2\pi.$$

When we were unsuccessful in producing a plot similar to the one in the article, a careful inspection of its listing 2 revealed the line

```
d(i,j)=SIN(r)+.5 / SQR((ix+3.05)^2
 +iy^2)
```

Unfortunately, the variable *iy* is never defined in the program (presumably Bourke intended to type *jy* instead of *iy*). This has the effect of leaving out the y^2 in the second term of the function, which has a drastic effect on the function. I do not consider myself a programming purist, but an experience such as this goes a long way toward making me want to use languages that require all variables to be declared before they can be used.

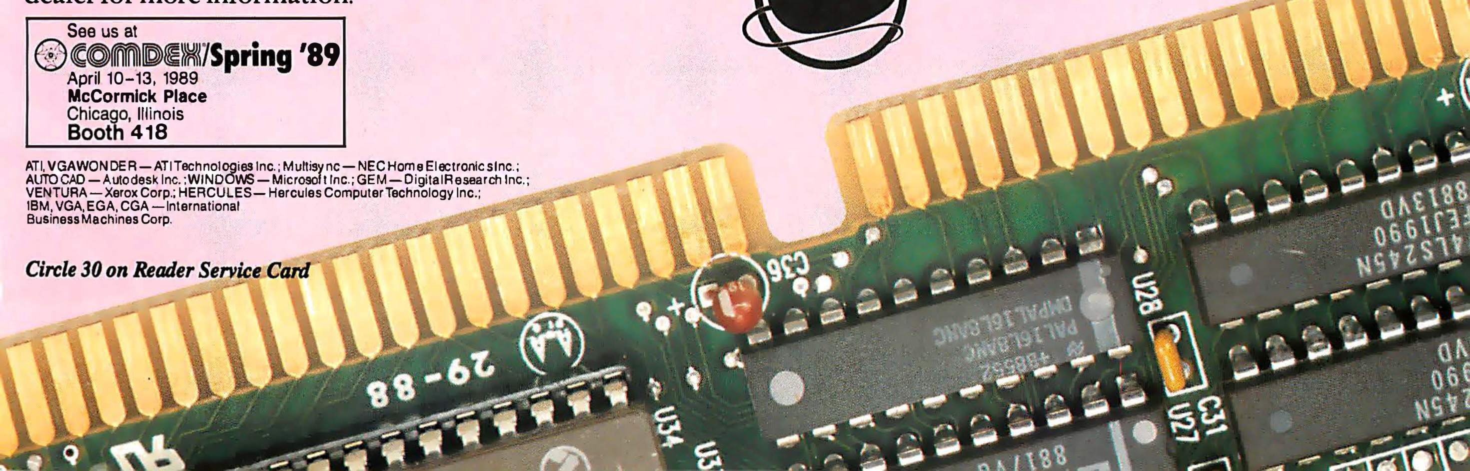
H. Joseph Newton
Professor of statistics
Texas A&M University

Time-slicing

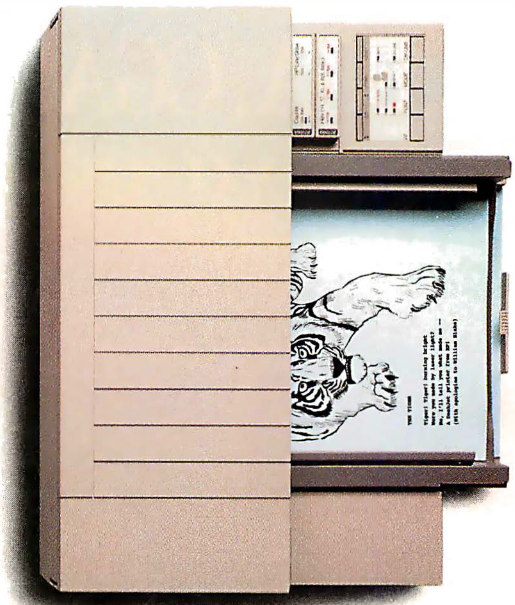
I am writing with regard to Mark Minasi's "OS/2's Multitasking Dashboard" (OS/2 Notebook, November 1988). Minasi is unable to explain why background processes get proportionately more CPU time as the time slice is increased (table 3 in the article). As far as I can work out, it is because when you increase the time slice, the ration of `maxwait` to `timeslice` decreases.

As an example, say there is one foreground and one background process running with `maxwait=1` (second) and `priority=dynamic`. If the time slice is

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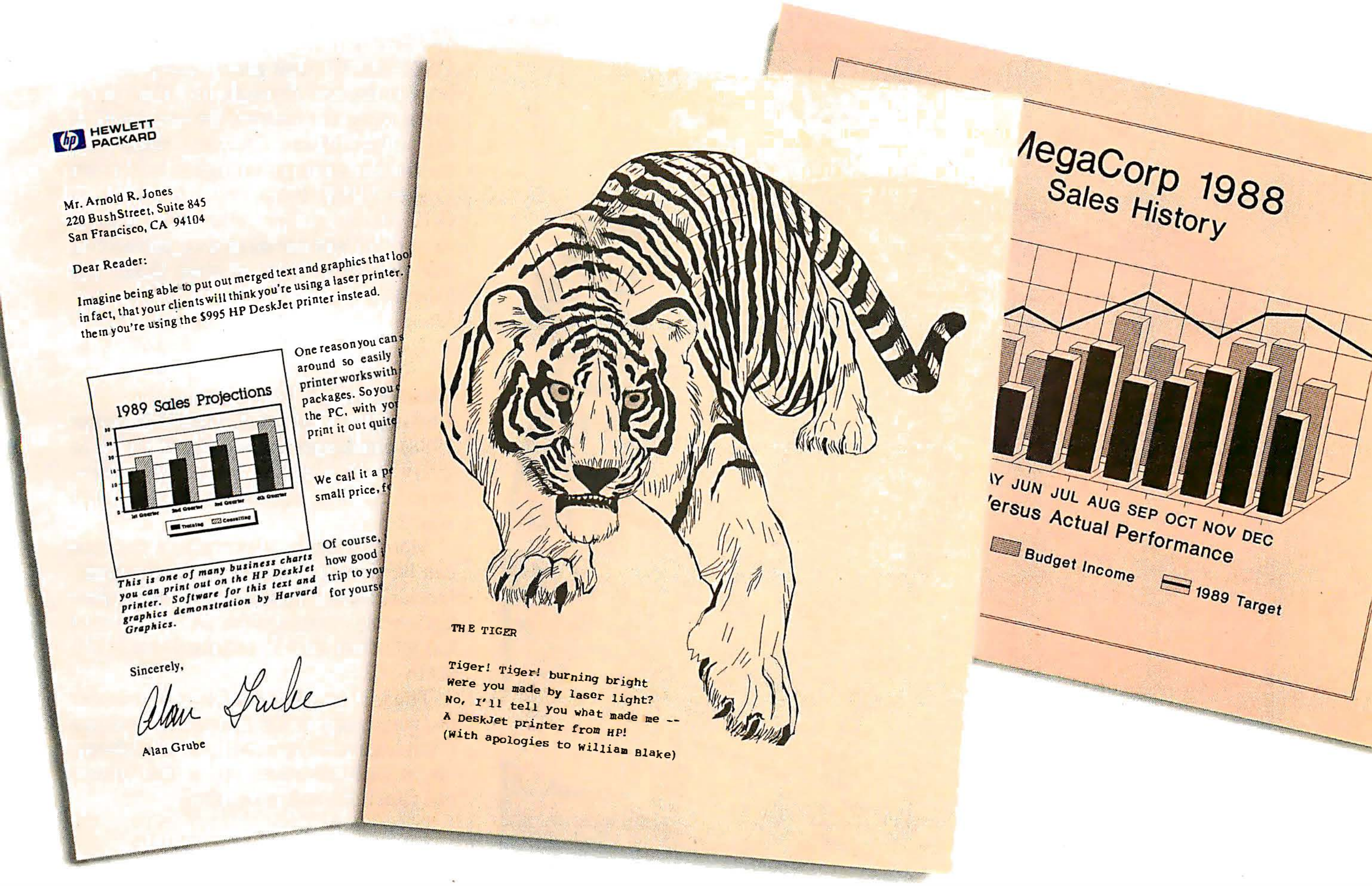


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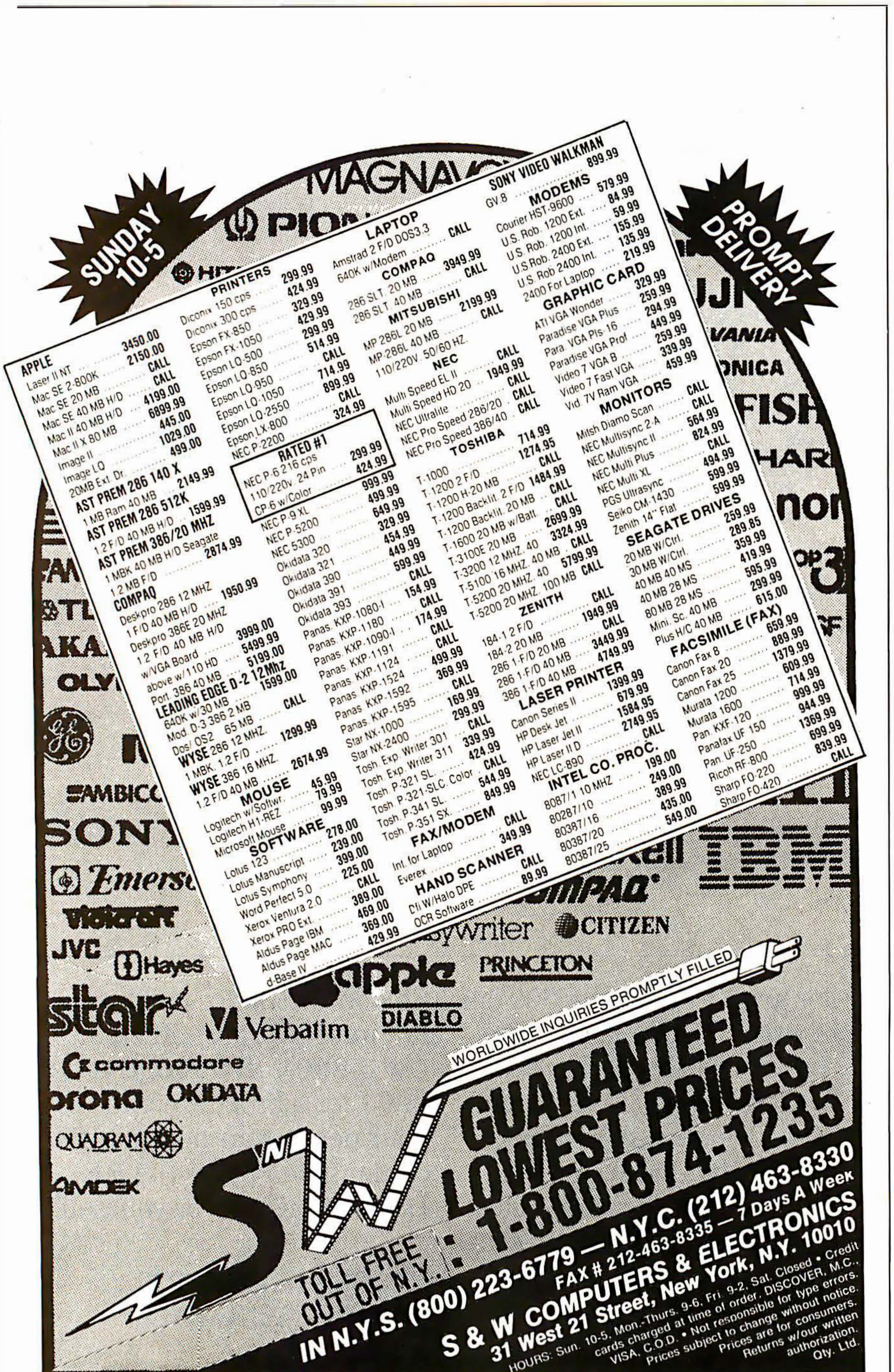
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set to 512 milliseconds, the foreground process will get two time slices before the background process receives a priority boost and runs a time slice. So the processor is split 2 to 1. When the time slice is increased to 1024 ms, the foreground process will now get one time slice before the background is boosted and gets a time slice. Now the processor is split 1 to 1. A similar thing will happen with more background processes. To show the task switch overhead, both `timeslice` and `maxwait` should be increased in proportion.

An OS/2 problem that I have is with IBM's 3363 Optical WORM (write once, read many times) drive. The application that we at my university are developing uses an IBM PS/2 Model 80 for imaging work, and we required a removable mass storage medium. Floppy disks have too small a capacity (about five images). The 3363 is the only such device that IBM supports for the PS/2 range. The trouble arises when you also try to use OS/2. OS/2 does not support the 3363, and IBM has no plans to release a device driver for it (as far as I have been able to find out). You cannot run the 3363 in the DOS box because it is a direct-access device driver, and these have to be written under OS/2 device driver rules.

IBM's suggestion to me (after many inquiries and much waiting) was to reboot the system into DOS after image acquisition and back up the images from the hard disk drive, then reboot back to OS/2—hardly idiot-proof, and it doesn't let you browse through the 3363 drive when using the system. Do you know of any other Micro Channel removable media that are large enough to hold many images (256K bytes each) and have an OS/2 device driver rather than a DOS driver? If there are no others, publicizing this deficiency may at least shake Big Blue up a bit.

Nathan Sidwell
Bristol, U.K.



The Akerman Function

Christopher Greaves (Letters, November 1988) challenges the readers of BYTE to deliver to him the value of Ackerman(5,5). The answer to this is simply Ack(5,5).

More seriously, Ackerman's function can be viewed as a definition of generalized arithmetic functions where the first argument is constant (value 2), the other has an offset of +3, and the value is offset by −3.

Thus, if op_m denotes function number m, where op_0 is the successor function (first argument ignored), op_1 is addition, op_2 is multiplication, op_3 is the "power of" function, and so on, then

$$Ack(m, n) = (2\ op_m\ (n+3)) - 3.$$

For the first four familiar functions:

$$Ack(0, n) = (2\ op_0\ (n+3)) - 3 = s(n+3) - 3 = n + 1$$

$$Ack(1, n) = (2\ op_1\ (n+3)) - 3 = (2 + (n+3)) - 3 = 2 + n$$

$$Ack(2, n) = (2\ op_2\ (n+3)) - 3 = (2 * (n+3)) - 3 = 2n + 3$$

$$Ack(3, n) = (2\ op_3\ (n+3)) - 3 = 2^{n+3} - 3$$

For op_4 I'm not sure of the standard nota-

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tion, but I think Donald Knuth has used ↑↑; that is,

$$x \operatorname{op}_4 y = x\uparrow\uparrow y,$$

where $x\uparrow\uparrow y$ is partially defined by

$$x\uparrow\uparrow 2 = x^x,$$
$$x\uparrow\uparrow y = x^{(x\uparrow\uparrow(y-1))}.$$

The function op_5 is defined in the same way in terms of op_4; that is, the general relationship is

$$x \operatorname{op}_1 y = x + y,$$
$$x \operatorname{op}_m 2 = x \operatorname{op}_{m-1} x,$$
$$x \operatorname{op}_m y = x \operatorname{op}_{m-1} (x \operatorname{op}_m (y - 1)),$$

for $m > 1$. An alternative answer, in terms of the more familiar arithmetic functions, is therefore

$$\text{Ack}(5,5) = (2 \operatorname{op}_5 (5+3)) - 3$$
$$= (2 \operatorname{op}_5 8) - 3$$

but that would be a matter of taste.

It is worth noting that this number is so large that, for example, conversion to binary form is impossible.

Alf P. Steinbach
Ringstad, Norway

Kludge Reduction Exercises

Recently, I wrote a parsing function that would accept up to eight filenames from within my program, storing each filename within an array of a string (i.e., `Array [1..8] of string`). I opened the files (`{$I-}`) and examined them to see if they existed. I tossed out incorrect filenames. I processed the remaining files and gave the processed files new names ending in .FIL to indicate that they had been "filtered." I won't show anyone the kludge I came up with, but with Dick Pountain's `Before()` and `After()` from "Untangling Pascal Strings" (December 1988), the whole mess reduced to only a few lines of code.

Although, as Pountain correctly states, the Turbo `Val()` function is happy accepting leading blanks, the same is not true when assigning filenames for `Reset()` and `Rewrite()`. For example, opening the file ' IN.DAT' is not the same as opening 'IN.DAT'. If a user decides to separate the files by two or more spaces, the `After()` function no longer works as desired. Instead of calling `Noblanks()` for each filename within my string array, I added another function, `DoubleCheck()`. This function (see listing 1) need only be called once to remove all multiple separators from the input string.

S. Balch
Lucan, Ontario, Canada

Listing 1: *Reader Balch's function to remove all multiple separators from the input string.*

```
Function DoubleCheck(S:String;
                     C:Char):String;
 Begin
   Repeat
     S := Before(S,C+C)
          + C + After(S,C+C);
   Until After(S,C+C) = '';
   DoubleCheck := S;
 End;

Example One

...
Readln(Tmpstr);
Tmpstr := DoubleCheck(Tmpstr,' ');
...
```

ASK BYTE

Disappointing Hard Drive

I wonder if you could advise me on available hard disk drive upgrades for my IBM PS/2 Model 50, which came with a disappointing CMS 20-megabyte 80-millisecond unit using an ST506 interface.

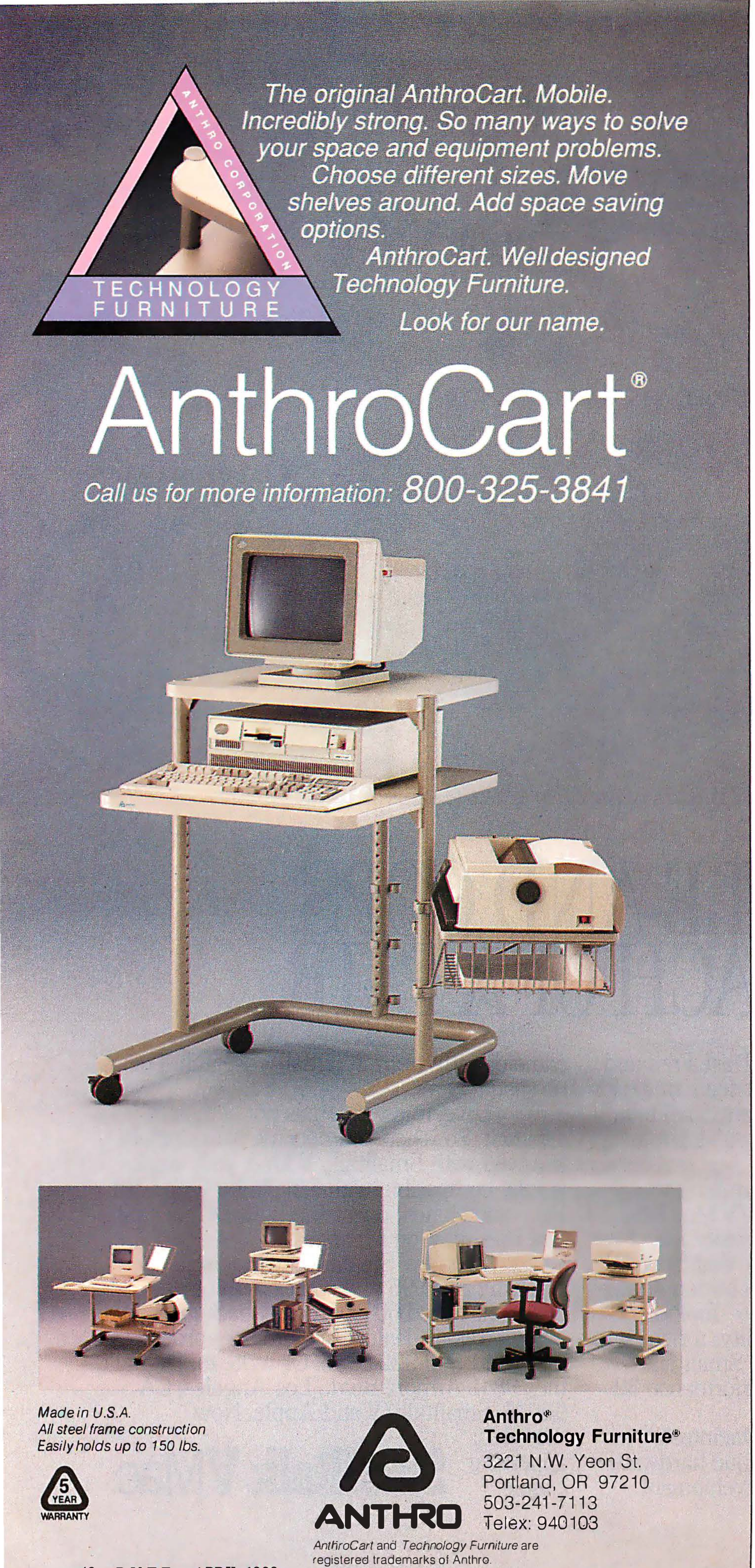
Antony Perakis
New York, NY

Unfortunately, independent companies have yet to penetrate the Micro Channel market. This is no accident. IBM has made it difficult for other vendors to support Micro Channel applications. The Model 50, in particular, causes difficulties for developers. The IBM BIOS supports only 17 sectors per track. Vendors cannot offer high-performance interfaces like run length limited or ESDI. They would either have to convince customers to throw out the IBM BIOS, or they would have to integrate a BIOS chip on the controller board. Since the market is limited to those Model 50 users who wish to upgrade from the included hard disk drive, it's a lot to ask of a vendor. Unlike the Model 60, which offers an extended CMOS RAM where developers have a window for modifications, the Model 50 offers no such luxury.

As of this writing, Adaptec is sampling a SCSI Micro Channel host adapter for OEMs. This product would not only provide an interface for hard disk drives, but it could also be used to add printers,

continued


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tapes, or scanners. Another product might let you hook to a network system through the SCSI port. Other Micro Channel products should be appearing soon, but they have been slow in coming. IBM does offer an upgrade path for your Model 50's hard disk drive: a 27-ms, 60-megabyte hard drive for $1695.—S. A.

Monochrome EGA

There are several expensive multiscan monochrome monitors that can be used with a conventional EGA card. Are there any *low-cost* monochrome EGA monitors?

Do special EGA cards that are capable of gray-scale shading on TTL monitors offer a good-quality display? Do they suffer from flicker, partial screen display, or distorted aspect ratio on any EGA modes?

Victor G. Apter
Buffalo, NY

EGA supports modes for monochrome display of both text and graphics. Therefore, you have a wide variety of low-cost monochrome monitors to choose from. I prefer the 14-inch models with a flattened screen. The September 1988 BYTE lists (in "Monitor Makers") contact information for the companies that manufacture such monitors.

I really like the output of gray-scale monitors, particularly the NEC Multisync GS (see "Review Update," September 1988 BYTE). The GS will accept TTL or analog video input and is compatible with a wide variety of video adapter cards. Our equipment did pick up excessive jitter, but the display is easier on the eyes than a no-frills TTL monochrome adapter and monitor. Not only is the gray-scale display visually appealing, but it adds functionality to programs that use color menus or extensive graphics. The monitor sells for under $300.—S. A.

From VIC to PC

In 1983, V. J. Georgiou, Ph.D., published the *VIC-20 Interfacing Blue Book*. It contained information on programs and inexpensive hardware for connecting resistance and capacitance meters and a few other nice peripherals. The one I found most interesting was the digital thermometer. It used a 555 timer, a few resistors, capacitors, and a thermistor. The book included the wiring diagram and programs to operate the thermometer. Even the Radio Shack part numbers were included.

Well, my VIC-20 is gathering dust somewhere in my basement, but I would

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still like to run some time-versus-temperature programs. I currently own an IBM PC XT clone, and I seem to remember a "Blue Book" for the PCs, but I have been unable to find such a publication. I have even started to plow through some books on the 8088 processor, but nothing there seems to be leading me toward my thermistor circuit. I realize I could buy a $300-to-$1000 add-on system to read temperatures into data files, but I don't require that level of sophistication. Do you know of any publications that might help?

Wayne A. Holmes
Monroe, CT

I've found two references that should help you.

Interfacing Your Microcomputer to Virtually Anything *by Joseph J. Carr (TAB Books, Blue Ridge Summit, PA: 1984) is not only a source of useful circuits, it's a good introduction to linear (analog) circuits.*

Handbook of Software and Hardware Interfacing for IBM PCs *by Jeffrey P. Royer (Prentice-Hall, Englewood Cliffs, NJ: 1987) should tell you how to put together your own interface boards for the PC and—most important—how programs can communicate with the interface.*

—R. G.

A Problem Solved

Regarding Lee Rose's letter (January Ask BYTE), there is a very viable solution to his problem of running IBM PC AT and Apple programs on the same machine. An Apple IIe or IIGS with Applied Engineering's PC Transporter card will provide most of the compatibility he is looking for. This card is available in a 768K-byte (Apple mode)/640K-byte (IBM mode) configuration. The CPU is a high-performance 16-bit V-30 microprocessor operating at 7.16 MHz. An 8087-2 math coprocessor slot (with an 8-MHz clock rate) is included.

I have used this card on my IIGS for some time now, and I have found the product easy to use and 100 percent compatible with MS-DOS 3.3, GWBASIC, dBASE II Plus, WordPerfect, Framework II, and Microsoft Windows applications. Also, I have easily converted Macintosh files to the IIGS using a modem. This setup, while not as inexpensive as an IBM clone, offers medium-priced compatibility with all three major formats—hard to beat!

Dene R. Francis
Charleston, SC

Thanks for the information.—R. G. ■

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CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics

Don't Knock Unix

This letter is a rather long flame engendered by your comments on Unix, which are summarized, I believe, by the following quote from your September 1988 Computing at Chaos Manor:

"This whole situation puzzles me. I've had a dozen people try to explain why you can't simply fire up Unix and use it as the master operating system to run multiple DOS programs, and the usual answer is, 'You can, but nobody's done it.' None of them can answer the next question," which you asked in the previous paragraph and which follows.

"Of course, I can also run standard Unix programs, but why bother? All the Unix programs that do the things I want to do have been pretty small potatoes compared to what's available on DOS."

Your comments are arrogant and nonsensical, and as a result, your readers might be deprived of the opportunities afforded by Unix.

To answer your first question, try out the Sun Microsystems 386i. Multiple DOS tasks can be run effortlessly or optionally menu-driven in a Unix environment. The cost for the mind-boggling capabilities of the 386i is about what you would pay for one of the more familiar 80386 systems with comparable hardware, with or without Unix.

The answer to your next question, "Why bother?," is necessarily more personal. Like you, I have a single-user system, a lowly 80286. Like you, I write as part of my living. Unlike you, I run Unix and would not touch DOS. Why do we differ? I imagine because we want different functions from the computer. For example, when I write, I must have copious references that are absolutely accurate, inserted with text citation styles that differ widely between publishers.

Under Unix, it is easy to take references from a commercial database with any format and incorporate them into a paper with any citation style and any bibliographic style. The programs that you link together to do this are part of the standard Unix operating system or in the public domain.

Under DOS, there are commercial programs to handle reference database reformatting, citation insertion, and references. But they are indeed overpriced and not flexible enough to satisfy the bizarrely idiosyncratic requests of scientific publishers.

The widely used DOS word processing programs that you appear to favor, such as WordPerfect, have been or are announced as being ported to Unix. Perhaps the reason you haven't seen them is that the Unix user typically does not like them. But they are indeed available. As for myself, there's no way that I would ever return to WordStar, which I used from the late 1970s through the mid-1980s.

Unix is an extremely comfortable computing environment. As evidence, consider the number of people you know who have voluntarily shifted from Unix to DOS, compared with the number who have become Unix users. You can easily tailor Unix to your wants. The standard Unix tools are renowned for their power and variety.

You may not need a multiuser, multitasking system, but it sure is nice, even for a "single user" like myself. Not everyone has the same needs and preferences. But I imagine that among your readers there are also some, perhaps many, who have needs like mine or for other reasons would be better satisfied by Unix than by DOS. Give them correct information, and after that let them decide for themselves.

John Rupley
Tucson, AZ

Thank you for your kind words.

I am well aware that the Sun workstations can do wonderful things; indeed, I

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. He can be reached c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "jerryp."

think I wrote at length about some of the work one of my friends did at Bellevue Hospital using a Sun. However, I haven't tried a Sun386i myself because I don't have one and because, up to now, those big Sun workstations have been well beyond the financial limits I generally impose on equipment I'll write about. I don't write about VAXes for the same reason.

Your statements about the 386i with Unix being about what you'd pay for "one of the more familiar 80386 systems with comparable hardware" is true only in the sense that you can load up anything. My Big Cheetah with everything aboard has a list price of only about $10,000. If I added Unix software, which is very expensive, that price would certainly rise.

Finally, your letter is typical of those I get. "Unix is wonderful, and I'm using it right now, and I can do all these terrific things." Fine, say I, and I invite Unix experts to come over here and set something up on one of my machines—and I have a lot of them.

The result so far has been a lot of good excuses. I have nothing against Unix, but I will not change my rules, which are that I write about what I'm using and that what I use has to work on equipment here at Chaos Manor and get done the jobs I have to do, such as writing books and columns and doing my taxes.

I'm glad you're happy with your system and that you like to `grep` *and* `urk`*.*

—Jerry

Exploit the Space Bar

Dear Jerry,

Recently, you've been trying to get us to use better keyboards. I have long wondered why designers haven't made better use of the space bar.

When there are 100 keys on a board for eight fingers, why is there one bar for two thumbs? In the search for more functions, why can't the bar be split in two—the right half for the right thumb, the left for the left thumb?

I'm all thumbs, but I bet I could train my right thumb to strike the right bar to move the cursor forward and my left thumb to strike the left bar to backspace.

Please put this suggestion in the public domain before someone claims "look and feel."

James T. Oitzinger
Houston, TX

That sounds like an interesting idea. I've been watching, and I hardly ever use my left thumb for anything. Fascinating. Thanks for the suggestion.—Jerry ■

C Programmers

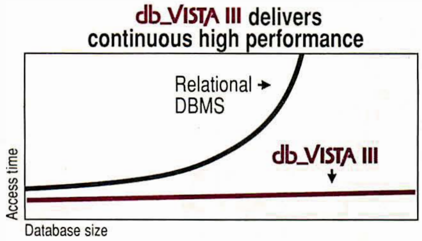


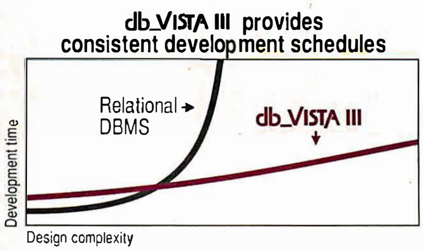
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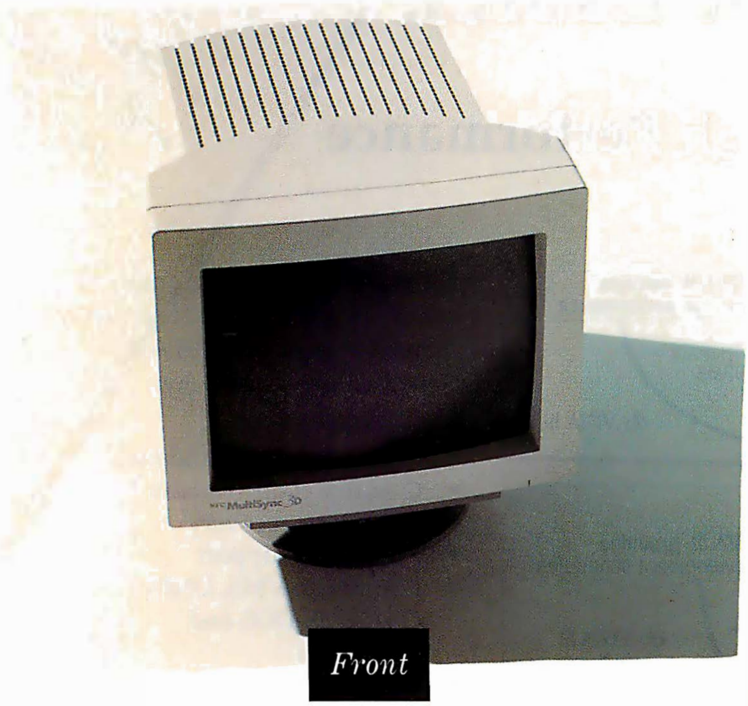
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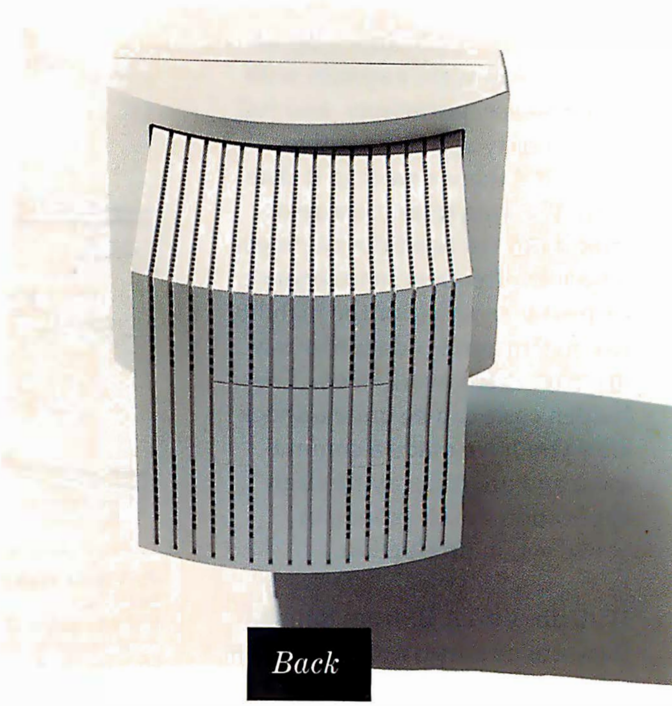
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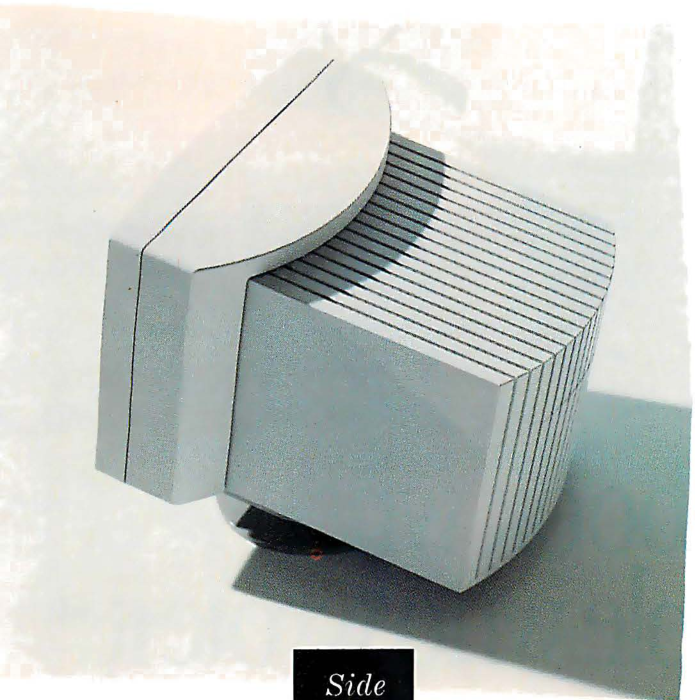
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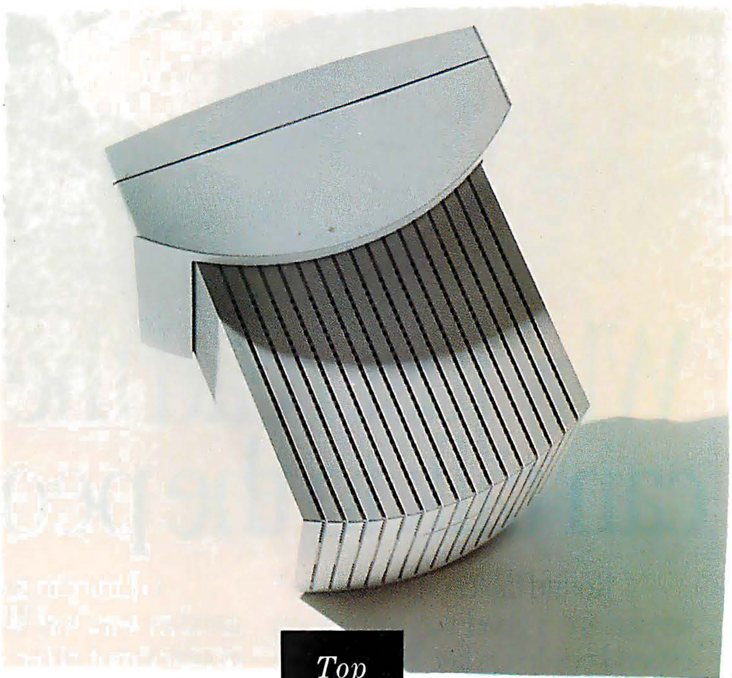
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The way we see it, MultiSync 3D



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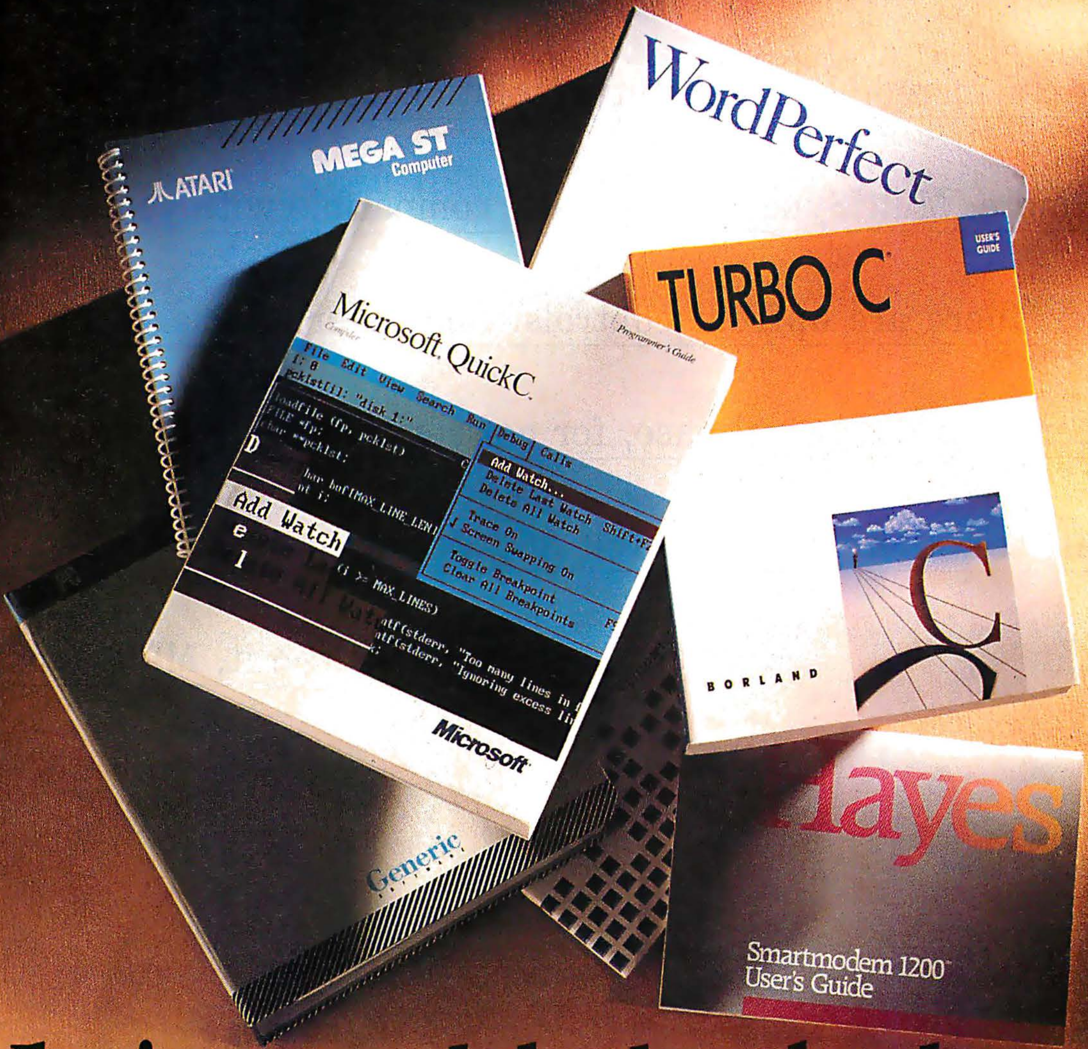


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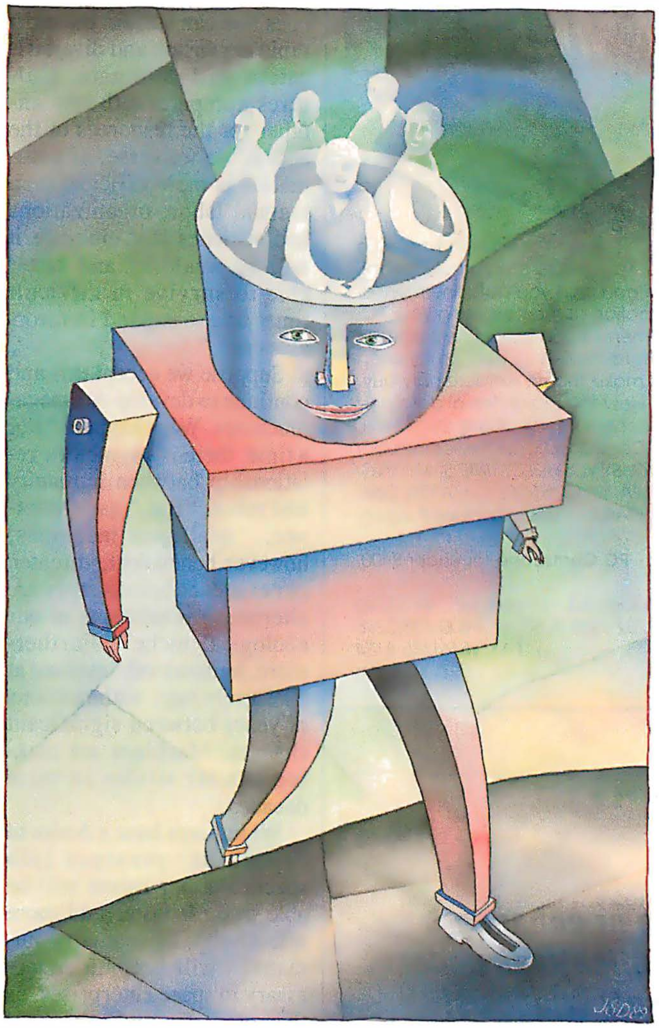
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Mind Children: The Future of Robot and Human Intelligence

by Hans Moravec

Harvard University Press, Cambridge, MA: 1988, 186 pages, $18.95

Reviewed by Eric Bobinsky



Although Marvin Minsky was using the phrase "meat machine" in the early 1960s to describe the human brain, this mechanistic viewpoint dates back to the industrial revolution and perhaps much earlier. For years, science fiction writers have constructed worlds in which robots equaled and even improved on human intelligence.

The idea that we humans will eventually build superintelligent machines that might replace us is hardly new, yet the AI community, which used to confidently proclaim it, has lately retreated to a much more conservative stance. After all, it is difficult to extrapolate the superhuman potential of our machines when, after 30 years of AI research, some of the simplest tasks performed by the "meat machine" cannot even be approached by our most advanced creations.

Thus, it is somewhat surprising when the director of Carnegie-Mellon University's Mobile Robot Laboratory writes a book on AI and robotics that stretches the limits of imagination. Hans Moravec's *Mind Children: The Future of Robot and Human Intelligence* goes far beyond the science fiction writers' view of superhuman robot intelligence and, without apology, dogmatically presents the author's ideas on the evolution of human and machine intelligence. It is one of the most fascinating books on the subject ever written.

Mind Children is the kind of book that makes readers react. They will argue with at least some of the author's ideas (I argued with quite a few). But that's not surprising, given the book's main premise that the biological evolution of humanity is complete, that the future will consist of a postbiological world dominated by our robots, and that we will eventually transfer our own minds directly into the machines we build. When speaking of current robot technology, Moravec writes that he sees "the beginnings of awareness in the minds of our machines—an awareness that I believe will evolve into consciousness comparable with that of humans."

Transferring our conscious selves into the minds of robots is an idea that might be safely relegated to the distant future—but coupled with it is the author's unequivocal statement that computers will have attained the processing power of the human brain within 40 years, which Moravec justifies by extrapolating from the rate of development of digital hardware since the time of Charles Babbage. So we aren't necessarily looking as far into the future as might allow us to comfortably contemplate this potential loss of human identity—perhaps only a few thousand years or less.

But creating a 10-teraops processor—which Moravec calls a "human equivalent computer"—isn't the ultimate goal. He goes on to discuss the possibility of protein robots that are genetically engineered to assemble circuits at the nanometer scale, allowing the creation of artificial brains millions of times more powerful than the human mind. Robots equipped with these brains might in turn be capable of using the ultradense matter of neutron stars to create processors that are one million million million million million times more powerful than the human brain by sidestepping certain currently accepted physical limits on the switching speeds of microcircuitry.

After taking the reader on a brief tour of theoretical physics and having tried to establish the feasibility of such ultrapowerful robot brains, Moravec moves into the realm of psychobiology. How will we be able to coexist with fellow creatures—for that is what our robots will become—that are clearly far superior to us in every respect? And, if that doesn't seem possible, should we even continue trying to develop them? What are the justifications for engineering our own obsolescence? Moravec writes, "The answer, I believe, is that we have very little choice, if our culture is to remain viable. Societies and

continued

ALSO REVIEWED

The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity

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economies are surely as subject to competitive evolutionary pressures as biological organisms. Sooner or later, the ones that can sustain the most rapid expansion and diversification will dominate. Cultures compete with one another for the resources of the accessible universe. If automation is more efficient than manual labor, organizations and societies that embrace it will be wealthier and better able to survive in difficult times and to expand in favorable ones."

Suppose we accept this and continue to develop our megamachines. What happens? For a time, there is a symbiotic relationship between humanity and robot. "But," says Moravec, "intelligent machines, however benevolent, threaten our existence because they are alternative inhabitants of our ecological niche." Furthermore, humankind "evolved at a leisurely rate, with millions of years between significant changes. Machines are making similar strides in mere decades."

We humans have a desire to expand our presence into space. But our robots will be able to do it faster and more effectively. "Eventually humans . . . will become unnecessary in space enterprises, as the scientific and technical discoveries of self-reproducing superintelligent mechanisms are applied to making themselves smarter still. These new creations, looking quite unlike the machines we know, will explode into the universe, leaving us behind in a cloud of dust."

The matter doesn't end there. Humans have a propensity for trying to better themselves, and what better way to do that than to have the mind transferred into a far superior, immortal robot body? We are immediately confronted with the mind-body problem of philosophy: Is the me in the new body really the old me? Or is it a perfect copy of the old me—and does it really matter? Two sections, "What Am I?" and "Awakening the Past," delve deeply into the problem.

Are there demons in this paradise of immortality and superintellect? "If the world of artificial machinery has seemed disease-free so far, it is only because our machines have been too simple to support mechanical parasites," writes Moravec in a section called "Trojan Horses, Time Bombs, and Viruses." In these pages (which are particularly interesting to read in light of the recent invasion of a nationwide Unix network by a computer science student's program), the author explores various types of digital fauna that can be made to infect and damage computer systems.

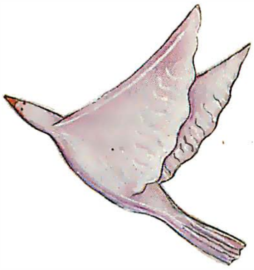
If robots can be made as complex as Moravec maintains, then we can easily imagine how susceptible they would be to equally complex parasitic programming. Furthermore, if we ourselves inhabit the robots, then the virus analogy becomes even more apropos. Here we have an entire system of artificial lifeforms: robots, human-robots, and the parasites infecting them—a concept Moravec calls "freely evolving digital wildlife." Parasitism, far from being undesirable, is necessary for triggering the mutations that will allow this system to continue to evolve. In other words, the transition from biological system to postbiological system is complete and irreversible.

Thus, we have built machines that are our postbiological successors. We have looked upon them and seen that they are good. And we have finally abandoned our bodies and moved to inhabit our machines. This has taken many years, but maybe not as long as we anticipated. We have had ample time to thoroughly explore our own universe, and probably others as well. But the universe must ultimately wind down—a victim of entropy death, tragically cutting short our reign of intellect. But not to worry—we are

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now even capable of forestalling the end of the universe by storing energy and releasing it at the proper moment. So our robots, which may be ourselves, have finally attained the stature of gods. But they have done so through what Moravec depicts as a necessary and logical progression in the evolution of the human brain, so perhaps the concept isn't as far out as it seems.

Mind Children is destined to be a controversial book. The margins on every other page of my copy are covered with question marks and exclamation points; it is impossible to read the book and be impartial. It has the accuracy of a college text and the can't-put-it-down appeal of a good novel. Moravec has turned the flights of mind of one of the world's foremost roboticists into hard copy. And he has written a tremendously good book in the process.

The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity

by Heinz Pagels

Simon and Schuster, New York: 1988, 352 pages, $18.95

Reviewed by David A. Mindell

Computers are symbolic machines. So stunning is their appetite for symbolic manipulation, however, that what we used to think of as the "meaning" behind our signals is often obscured by the proliferation and seeming self-replication of machine codes. From bar code to source code, from ISDNs to ICBMs, our culture seems headed for a digital meltdown. Antiquated modes of thought may soon be unable to extract signals from the parasitic noise of the once-hailed Information Society.

Heinz Pagels presents a perspective that would prevent such confusion. In his book *The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity*, he explores how, through computers, we are acquiring the insights required to reverse the tide of cultural entropy and find order in what was previously perceived as chaos. Pagels uses the term "complexity" to describe recent and startling developments in the sciences that have the potential to displace earlier scientific models. These developments are largely a result of the advent of the computer as an instrument of inquiry, and they also display an amazing similarity to the workings of nature itself.

Pagels, who died last year, was executive director of the New York Academy of Sciences and a physicist at Rockefeller University. In *The Dreams of Reason* he thoughtfully explores some of the new "sciences of complexity": chaos theory, computational biology, computer simulation, neural networks, and the increasingly complex web of financial computer networks. He goes on to a thorough and detailed consideration of the philosophical and cultural implications of a scientific paradigm of complexity.

The term "complexity" is itself the first complex concept of the book, because it has numerous meanings and implications and simply cannot be tied down to any one. Pagels's loose definition is that complexity lies between order and chaos. On one hand, a crystal, with its regular rows of atoms, is "ordered" and can be easily known or determined. Completely chaotic systems like gases, on the other hand, can be well understood because "we can apply the laws of statistics to them with great effect."

Complexity could be said to lie between determinism and statistics, a difficult and shady region without clear boundaries. One measure of the

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complexity of a system is "algorithmic complexity," or the size of the system's minimal description. Pi, for example, though an infinitely long real number, is not particularly complex because you can write a relatively simple program to compute it. Another kind of complexity is "computational," which would measure not the size of the program but how long it would take to run.

The problem with these and other quantitative descriptions of complexity that Pagels explores is that they do not lie solidly between order and chaos. The "algorithmic" measure, for example, would ascribe a higher degree of complexity to a random string than to one with some inherent order. Of course, all these measures fail with language, while simple and ordinary sequences of words can be used to describe extraordinarily complex concepts: "To be or not to be." Pagels fails to discover an adequate and binding definition for complexity. Instead, he presents, in a suitably complex mode, several qualities or "themes" shared by complex systems:

- They tend to be selective systems, employing, like evolution, the principle of "survival of the fittest."
- They tend to emphasize parallel over serial processes.
- They often discover new principles based on nature.

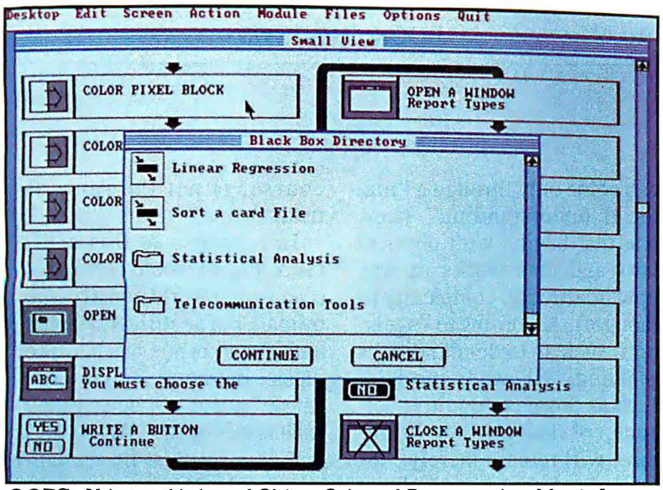
Despite the difficulties of numerical or verbal description (there is no adequate theory of complexity; that's why it's new), Pagels's chapters on the sciences of complexity are rigorous and spirited enough to convey to the reader an intuitive sense of the nature of complexity. For example, on mathematics, Pagels comments, "I believe that it is because of the possible complexity arising out of a simple logical system that mathematics acquires its quality of independence and autonomy from the mind."

The entire first half of *The Dreams of Reason* reads like a review of recent popular scientific literature (although Mandelbrot and his fractals are curiously absent). Pagels reviews the startling new theory of chaos, as laid out in James Gleick's recent book. Chaos theory has been used to describe everything from global weather patterns to leaky faucets, and recently even the behavior of computer networks. Such systems are characterized by extreme nonlinearities, which results in an almost infinite sensitivity to initial conditions. Thus, even if the laws governing a chaotic system are known, such a system cannot be simulated without defining its initial state to anything other than infinite precision, which is impossible.

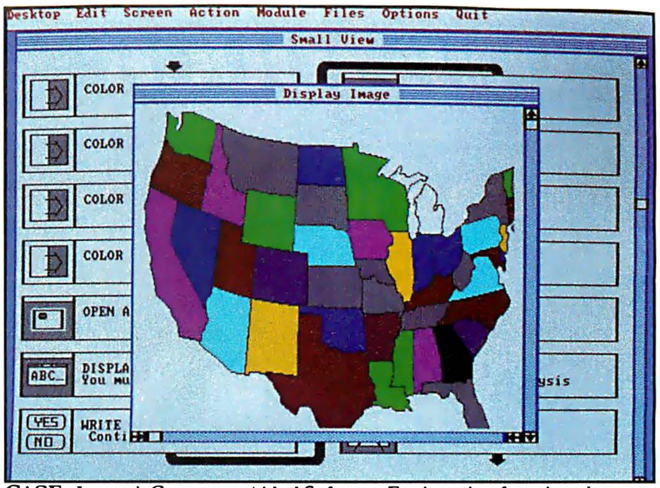
The next chapter is on cellular automata, sophisticated versions of the popular computer game called Life that can simulate complex biological systems. With such tools, scientists watch the evolution of pseudobiological systems and have observed some fascinating phenomena: a) The "cells" of the simulation tend to get trapped in a given configuration, but not necessarily in the optimum one for survival; b) when they do achieve an optimum form, they may not be able to maintain it in the face of recurring mutation; and c) a large amount of spontaneous order arises in the evolutionary process. How well these simulations match the operations of natural evolution can be debated, but they certainly provide insights into the workings of more artificial parallel and selective complex systems.

The second part of *The Dreams of Reason* is dedicated to Pagels's philosophical musings on the implications of the sciences of complexity. He addresses the most complex system known to man: the human brain. He insists that a fundamental understanding of the brain and human cognition

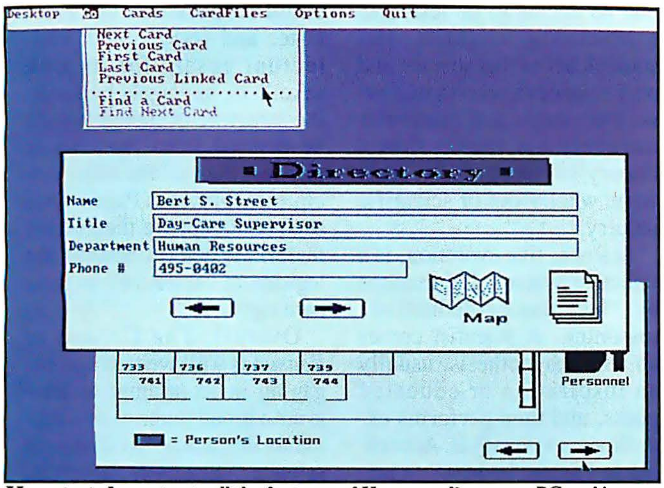
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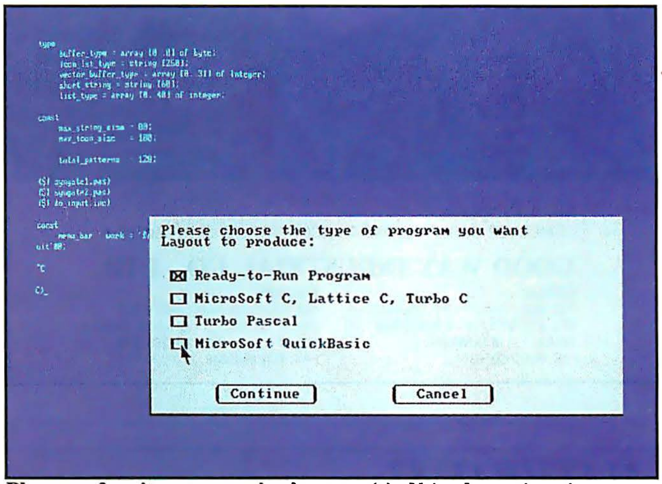
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can come only through a "material understanding" (i.e., one that begins with physical laws and then works its way upward through complexity to thought). According to Pagels, until such an understanding is reached, all other models, such as those of cognitive science, philosophy, or literature, will remain merely "intellectual fashion." He is consistently and harshly critical of the conclusions of anyone he deems to be less than a practicing scientist. His staunch belief that science and only science expresses universal truth limits and eventually unravels his thesis that a theory of complexity must come wholly out of scientific inquiry.

Science, like evolution, is a selective system. It functions by "hypothetico-deductive" reasoning. A scientist comes up with a hypothesis, usually an inspiration or educated guess, and then performs experiments to verify it. According to Pagels, however, a scientific theory can never be proved true, it can only be proved wrong.

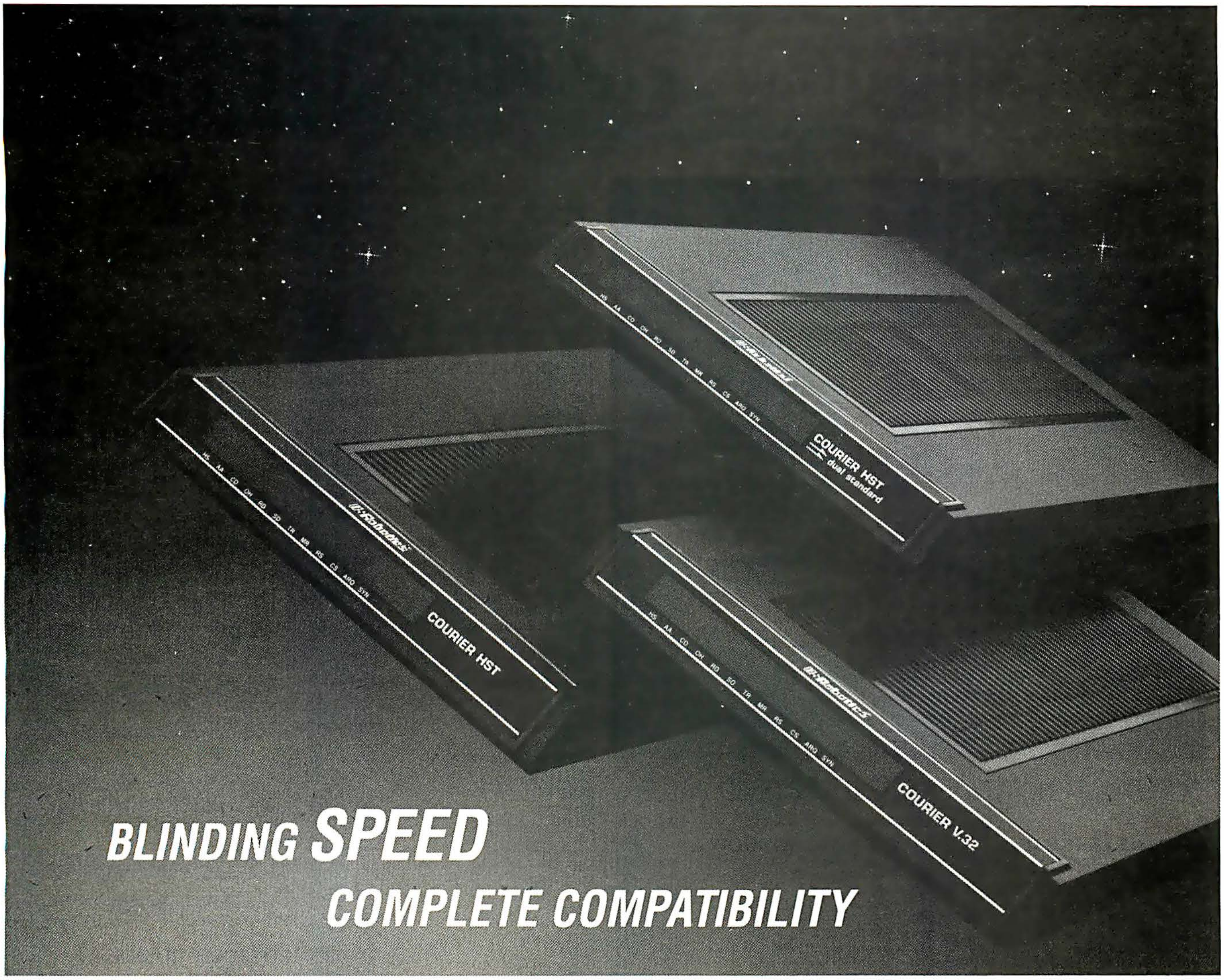
Revolutionary theories, like those of relativity or quantum mechanics, acquire a certain credibility if they survive long enough without being disproved, but they still cannot be proved positively. Thus, the evolution of science is like the evolution of life; the fittest survive the tests of time, but not necessarily as the optimum configuration. This is a valid and logical explanation of the progress of science. The problem, however, is that Pagels's writing is simultaneously infused with the opposite view—namely, that science expresses absolute and unshakable truth, knowing nature in a positive sense from "the bottom up." This belief is at odds with the evolutionary view of science, which tells us that, like cellular automata, scientific theories do not necessarily settle in the optimal configuration, only one that will survive. And, as Pagels himself says, "Survival, of course, is not the same as truth."

In response to this criticism, Pagels would admit that science is a world constructed by man, but he still sets it apart and above other worlds like music, literature, and law because "it was not determined exclusively by us." Pagels says that as a scientist he remembers only "concepts and facts," as opposed to "humanists" whose thought is "dedicated to political opinion, taste, and style. . . and intellectual gossip for its own sake." If, as Pagels believes, the structure of thought could be derived from the laws of physics, then all the other disciplines for which Pagels feels such contempt are themselves materially determined and are legitimate "sciences" in their own right.

Overall, *The Dreams of Reason* is well written and engaging in its attempt to integrate a broad range of developments into a new "synthesis of science." The irony, however, is that Pagels's refusal to recognize ideas from those people who are not practicing scientists grounds his discourse in a deterministic, noncomplex paradigm. His difficulty with defining complexity, for example, would certainly be eased by considering other postmodern thinkers, such as philosopher Gilles Deleuze, historian of science Michel Serres, or even novelist Thomas Pynchon. The sciences of complexity are interdisciplinary. A vision that integrates computers and biology, as well as neurology and quantum mechanics, should be able to accommodate the complex philosophies of thought and language in its quest to select a theory of the shining but presently uncharted region between order and chaos. ■

CONTRIBUTORS

Eric Bobinsky works at the NASA Lewis Research Center in Cleveland, Ohio. **David A. Mindell** is a technical writer and consultant living in Aspen, Colorado.



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Greenleaf Functions	209	155
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PC-lint	139	101
PCYACC	395	359
TimeSlicer	295	279
w/ source	1000	899
Turbo C TOOLS/2.0	149	115
vLIB	99	89
w/ source	149	129

C GRAPHICS

	LIST	OURS
Essential Graphics	299	229
w/ source	595	509
GraphiC	395	322
GSS Graphic Dev. Toolkit	595	509
HALO '88	325	229
HALO '88 for MS Devel.	595	399
TurboHALO	100	80

C SCREENS/WINDOWS

	LIST	OURS
Curses (Aspen)	159	145
w/ Source	349	319
C-Scape	299	282
w/ Look & Feel	399	379
C-Worthy	195	165
w/ Forms & Source	495	439
Greenleaf DataWindows	295	209
Greenleaf Makeform	125	90
HI-SCREEN XL	149	129
JAM	750	684
JYACC FORMAKER	495	453
PANEL Plus	495	395
Vermont Views	395	CALL
w/ Source Code	790	CALL
Vitamin C	225	162
VCScreen	149	109

COBOL LANGUAGE

	LIST	OURS
Micro Focus:		
COBOL/2 w/ Toolset	1800	1465
COBOL/2 Toolset	900	733
PC-CICS	1495	CALL
Personal COBOL	149	121

COMMUNICATIONS

	LIST	OURS
Carbon Copy Plus	195	135
Close-Up (Support)	245	222
Close-Up (Customer)	195	116
Co/Session (2 user license)	249	227
Support	175	157
Application	125	116
MIRROR III	100	90
RELAY Gold	250	229
RELAY Silver	150	139

dBASE LANGUAGE

	LIST	OURS
CLARION	695	599
Clear +	200	165
Clipper	695	439
dBASE III Plus	695	399
dBASE IV	795	485
dBASE Graphics for C	90	69
dBASE ON LINE	69	60
dBASE Programmers Utilities	90	79
dBASE Tools for C	90	69
dBASE Tools for Pascal	90	69
dBFast	100	75
dBUG	195	179
dQUERY	150	129
Flipper	195	182
FoxBASE +	395	249
Genifer	395	259
Integrated Dev. Library	149	135
Paradox v. 3.0	725	539
QuickSilver	599	369
R:Base for DOS	725	529
R & R	150	129
w/ Clipper/FoxBASE module	199	179
Say What!	50	45
Scrimage	CALL	CALL
SilverComm Library	150	139
The Documentor	295	229
Tom Rettig's HELP	120	CALL
Tom Rettig's Library	100	80

	LIST	OURS
UI Programmer	295	229
XDB-SQL	495	419

DEBUGGERS

	LIST	OURS
386 DEBUG	195	145
Periscope I/512 K	795	675
Periscope II	175	155
Periscope IIx	145	129
Periscope III	1395	1255
Quaid Analyzer	200	179
Sherlock	195	179

DESKTOP PUBLISHING

	LIST	OURS
HALO DPE	195	162
MKS SQPS	495	479
Pagemaker	695	523
Ventura Publisher	895	525

DISK/DOS UTILITIES

	LIST	OURS
Command Plus	90	70
Command Tips	90	80
Disk Optimizer	60	55
FANSI CONSOLE	75	66
FASTBACK Plus	189	142
hTest: hFormat	90	80
MACE Utilities	99	90
Magellan	139	CALL
MKS Toolkit	199	165
Norton Commander	89	56
Norton Utilities	100	61
Norton Utilities, Adv. Ver.	150	101
PC/Tools Deluxe	80	70
Vcache	50	47
Vfeature	80	75
Vfeature Deluxe	120	111
Vopt	50	47
Xtree	70	60
Xtree Pro	129	111
ZYINDEX 3.0	95	85
ZYINDEX PROFESSIONAL	295	265

EDITORS

	LIST	OURS
BRIEF	195	CALL
Epsilon	195	151
KEDIT	150	120
ME	89	79
w/ source	189	169
MKS VI	149	125
Multi-Edit	99	90
Norton Editor	75	70
PC/EDT +	295	269
Pi Editor	149	129
Slick Editor	195	155
SPF/PC	245	185
VEDIT PLUS	185	115
Vq	270	CALL

FILE MANAGEMENT

	LIST	OURS
Btrieve	245	185
Xtrieve	595	459
Report Executive	145	109
Btrieve/N	595	459
Xtrieve/N	595	459
Report Option/N	345	279
CBTREE	159	141
C-Index for MSC	195	175
C-Index for Turbo C	100	90
C-Index Plus	395	349
c-tree	395	318
d-tree	495	395
r-tree	295	241
c-tree/r-tree bundle	650	523
CQL Query System	395	332
dBC III	250	CALL
dBC III PLUS	750	CALL
db_FILE	395	309
db_RETRIEVE	395	309
Essential B-Tree	99	89
w/ source	198	179
XQL	795	599

FORTRAN COMPILERS

	LIST	OURS
F77L	477	429
GRAPHER	199	179
Lahey Personal FORTRAN 77	95	89
MS FORTRAN	450	299
RM/FORTRAN	595	479
SURFER	399	359

FORTRAN LIBRARIES/UTILITIES

	LIST	OURS
FITLIB	350	305
FFTLIB	350	305
Grafmatic	135	119
MINIPACK1-LIB	350	305
Plotmatic	135	119
SPARSGEM	350	305
Spindrift Library	149	135
Tekmar Graphics Library	195	169

LINKERS/LIBRARIANS

	LIST	OURS
OPTLIB	49	45
OPTLNK	125	109
Plink86plus	495	279
Plib	195	149
PolyLibrarian I	99	90
PolyLibrarian II	149	131
.RTLink	195	185

MODULA-2

	LIST	OURS
JPI Top Speed Modula-2	100	90
LOGITECH Modula-2 Development System	249	199

	LIST	OURS
Solid B + Toolbox	100	90
Stony Brook Modula-2 Development Package	345	309

OBJECT-ORIENTED PROGRAMMING

	LIST	OURS
ACTOR	495	423
C_talk	150	129
C_Talk/Windows	450	399
Smalltalk/V	100	85
Communications	50	45
EGA/VGA Color Ext.	50	45
Goodies #1, #2 or #3	50	45
Smalltalk/V286	200	169
Smalltalk/V MAC	200	179

OPERATING SYSTEMS

	LIST	OURS
Microport:		
System V/AT (complete)	649	549
AT Runtime System	249	209
286 DOS Merge	249	209
SCO:		
XENIX Sys V (comp.)	1295	999
Operating System	595	479
WENDIN:		
Operating System Toolbox	99	80
PCNX	99	80
PCVMS	99	80
Wendin-DOS	139	109

OS/2 DEVELOPMENT TOOLS

	LIST	OURS
Btrieve for OS/2	595	455
Epsilon for OS/2	195	151
Greenleaf DataWindows	395	CALL
GSS Dev. Toolkit for OS/2	CALL	CALL
LOGITECH Modula-2	349	279
MKS AWK (OS/2)	179	159
MKS Toolkit (OS/2)	495	439
MS Languages	CALL	CALL
NeWS/2	495	CALL
Panel Plus for OS/2	495	395
PolyAWK for OS/2	199	179
Vitamin C (OS/2)	345	279
Windows for Data (OS/2)	395	349

PROTOTYPING

	LIST	OURS
Dan Bricklin's Demo Program II	195	179
Instant Replay	150	131
Proteus	149	129
Screen Machine	79	60
Show Partner	99	89
Show Partner F/X	350	319

REFERENCE GUIDES

	LIST	OURS
Command Tips	90	80
Norton On-Line Prog. Guide	100	75
Tom Rettig's HELP	120	105

PASCAL COMPILERS

	LIST	OURS
Microsoft Pascal	300	189
Turbo Pascal	150	112
Turbo Pascal 5.0 Professional	250	187

TURBO PASCAL LIBRARIES/ UTILITIES

	LIST	OURS
B-tree Filer	125	99
DATABOSS	399	359
Pascal ASYNCH MANAGER	175	137
PCX Toolkit	90	80
POWER SCREEN	129	99
Turbo Analyst	99	79
Turbo ASYNCH MANAGER	129	99

NEW RELEASES

Vermont Views 1.0
Vermont Creative Software's new generation of Windows for Data. User-interface library for forms, windows, menus, help, and key-board handling. Menus in any style. Forms can be larger than display window, have choice lists, context-sensitive help, flexible decimal, date, time, and toggle fields. Mini word processor. International language portability.
List: $395 **Ours: CALL**

Microsoft QuickC V. 2.0
Now features incremental compilation and linking, resulting in greatly improved compilation speed. Also now includes a built-in, in-line assembler. Hypertext technology has been utilized in QuickC's new on-line reference system.
List: $99 **Ours: $69**

.RTLink
Fast, new overlay linker. User RTLs (Run Time Libraries) to prevent repetitive storage, on disk, of code that is common from one .EXE file to the next. Use of .RTLs results in significantly smaller .EXEs resulting in reduced disk space requirements.
List: $195 **Ours: $179**

A T R O N

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Circle 31 on Reader Service Card

In Europe, contact:

Elverex Limited, Enterprise House
Plassey Technology Park, Limerick, Ireland
Phone: 061-338177

QA Training Limited, Cecily Hill Castle
Cirencester, Gloucestershire, GL7 2EF, England
Phone: (0285) 5888

Network Station Designed Around X Windows

The NCD16 is a 12.5-MHz 68000-based personal computer with 1 megabyte of RAM. It's built in the tradition of the low-priced, intelligent personal computers that boot from an Ethernet host.

This intelligent workstation, however, is designed to also run X Windows software, an MIT-designed software concept that has been endorsed by IBM, DEC, Hewlett-Packard, and others. X Windows lets the NCD16 support multiple applications running on hosts under the Unix and VMS operating systems; it runs the applications between the hosts and the NCD16 at the 10-Mbps Ethernet data rate. (Compare that to the maximum ASCII terminal-to-host rate of 38.4 kbps.)

Once you've downloaded X Windows from your host (or you've booted up with an optional PROM), you address particular hosts with the mouse by clicking on the representative windows. The 16-inch monochrome display with 1024- by 1024-pixel resolution promptly responds with a 105-dpi bit-mapped graphic, something available before only on stand-alone PCs, proprietary LANs using data rates afforded by optical fiber technology, and higher-priced workstations.

The Ethernet adapter fits into the NCD16's only slot.
Price: $2550; PROM, $300.
Contact: Network Computing Devices, Inc., 350 North Bernardo Ave., Mountain View, CA 94043, (415) 694-0650.
Inquiry 1151.



The X Window-based NCD16 computer has an Ethernet link.

This 80386 System Eliminates the 80286 Price Advantage

The Power 386-20 might just be the least-expensive 80386-based personal computer on the market. And it's not short on equipment. It comes standard with 1 megabyte of RAM, a 30-megabyte hard disk drive, a 1.2-megabyte 5¼-inch floppy disk drive or a 1.44-megabyte 3½-inch floppy disk drive, and a 12-inch monochrome monitor.

There's also a Hercules-compatible graphics card, a 101-key Key Tronic keyboard, and room for five 16-bit and three 8-bit add-in cards.

Other standards include a 1-to-1 interleave controller for two hard disk drives and two floppy disk drives, a parallel port for your printer, and room for two half-height internal peripherals and three half-height external drives.
Price: $1995.
Contact: Micro 1, Inc., 557 Howard St., San Francisco, CA 94105, (800) 338-4061; in California, (415) 974-5439.
Inquiry 1153.

A Desktop with a Mainframe Punch

The Unisys Micro A is a redesign of the PW² Series 800 with a mainframe processor.

Basically, Unisys took an off-the-shelf 80386-based workstation, converted the 80386 processor into an I/O and maintenance subsystem, and added a 48-bit mainframe A-series processor, an 80286 data communications coprocessor with four ports, and a Z80 SCSI coprocessor.

With the 16-bit 80386 acting as an I/O system, Unisys limits the power of the 48-bit main processor, company officials admit. Similarly, an 80286-based data communications processor with four RS-232C communications ports is overkill.

However, Unisys says that the goal was to design a desktop system that would bring down the price of a Micro A, whose predecessor is priced at about $100,000. Upgrades with X.25 capabilities are planned.

Without modifications, the PW² Series 800 runs both OS/2 on the 80386 and the Series A Master Control Program/Advanced System (MCP/AS), which is the mainframe operating system designed for the A Series. It can also run as an 80386 with OS/2 alone.

At the heart of the Micro A processor is the single-chip A-Series mainframe processor, a 2- by 2-inch multichip package that contains the equivalent of 10.3 million transistors. The processor sits on a thick (two-board-width) AT add-in board within the 16-bit 80386-based motherboard. The processor board contains 2.5 megabytes of static RAM plus 12 megabytes of system RAM. The 80386-based motherboard contains 3 megabytes of RAM.
Price: $25,365; software, $5000.
Contact: Unisys Corp., P.O. Box 500, Blue Bell, PA 19424, (215) 542-6512.
Inquiry 1150.

continued

SEND US YOUR NEW PRODUCT RELEASE
We'd like to consider your product for publication. Send us full information, including its price, ship date, and an address and telephone number where readers can get further information. Send to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Information contained in these items is based on manufacturers' written statements and/or telephone interviews with BYTE reporters. BYTE has not formally reviewed each product mentioned. These items, along with additional new product announcements, are posted regularly on BIX in the microbytes.sw and microbytes.hw conferences.

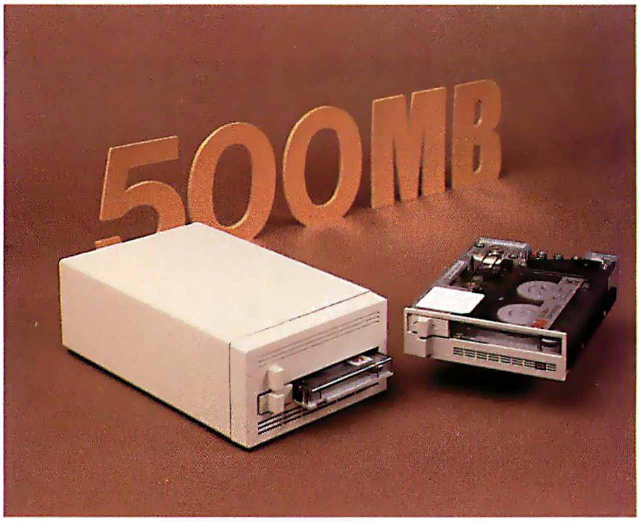
Please, Squeeze My Data

When first approached with a real-time compression algorithm that would effectively double the number of bits it could squeeze into its QIC-40 streaming tape drives, Colorado Memory Systems said "No, thanks" to Stac of Pasadena, California.

But on further consideration, the company that made the QIC-40 a de facto standard decided to work with Stac to use the algorithm, as well as to promote it as the perfect data compression software for streaming tape drives.

The company also decided that the length of the tape could be increased from 600 feet to 1000 feet because, unlike standard audiocassette tapes, the drive mechanism that pulls the tape through the heads isn't the tape itself.

The result is the QFA-500, with 500 megabytes of memory backup capacity. It sits in a 5¼-inch form factor and backs up data at 4 to 6 megabytes per minute, depending on the data. Each QFA-500 needs 512K bytes of system RAM.
Price: $1395; external, $1795; XT/AT adapter, $150; PS/2 adapter, $300; tape cartridge, $43.40.
Contact: Colorado Memory Systems, Inc., 800 South Taft Ave., Loveland, CO 80537, (303) 669-8000.
Inquiry 1155.



Data compression makes the QFA-500 a 500-megabyte tape drive.

Lundy Monitor Features 1600 by 1200 Resolution

The Lundy 1612 is a 1600- by 1200-pixel color graphics monitor for the IBM AT, PS/2s, and compatibles. It comes with a high-speed graphics controller and support for leading software packages.

Besides the 19-inch CRT unit, the Lundy 1612 includes an interface board installed inside the host computer, and an external box (typically sitting below the monitor's swivel stand) that holds the graphics controller and video RAM on two separate circuit boards. Interfaces are available for both the 16-bit AT bus and the Micro Channel bus, and Lundy plans to announce boards for other systems later this year. The standard AT board comes with a megabyte of video RAM.

The graphics controller uses proprietary ICs and the 50-MHz Texas Instruments TMS 34010—a 32-bit graphics processor that TI says is capable of drawing at the rate of 6 MIPS. The controller/monitor combination can display up to 16 colors simultaneously from a palette of 4096 at 1600- by 1200-pixel resolution, or, with software reconfiguration, 256 colors from a palette of 16 million at 1024- by 768-pixel resolution. The video RAM is up to 8 megabytes.

The company claims compatibility with more than 100 software packages.
Price: $9950; MCA version, $10,150.
Contact: Lundy Electronics & Systems, Inc., Computer Graphics Division, One Robert Lane, Glen Head, NY 11545, (516) 671-9000.
Inquiry 1157.

Dot Matrix Just Got Better

The Proprinter X24E and XL24E are 24-wire, bidirectional dot-matrix printers rated at 288 characters per second in 12-character-per-inch draft mode. That's about 20 percent better than their predecessors, IBM says.

The print buffer has been enlarged to 14K bytes. The FontSet option provides for 11 additional fonts, and there's now a display panel for setup where there used to be DIP switches. You also get more paper-handling, paper-width, paper-weight, and programmable features than you probably care to have.

The printer's computer interface is parallel or, optionally, RS-232C or RS-422.
Price: X24E, $899; XL24E, $1199.
Contact: Consult your local telephone book's white pages for IBM Corp. or call (800) 426-2468.
Inquiry 1156.

Replace Mac's Mouse and Keyboard with Speech

Move down! Move right! Double-click!

You've just told your Macintosh to open an application. And you didn't need to use the mouse. You did it by speaking into a microphone.

That's what the new Voice Navigator from Articulate Systems can let you do. After teaching the Voice Navigator a basic vocabulary of commands, you can run applications and perform complex operations entirely by voice.

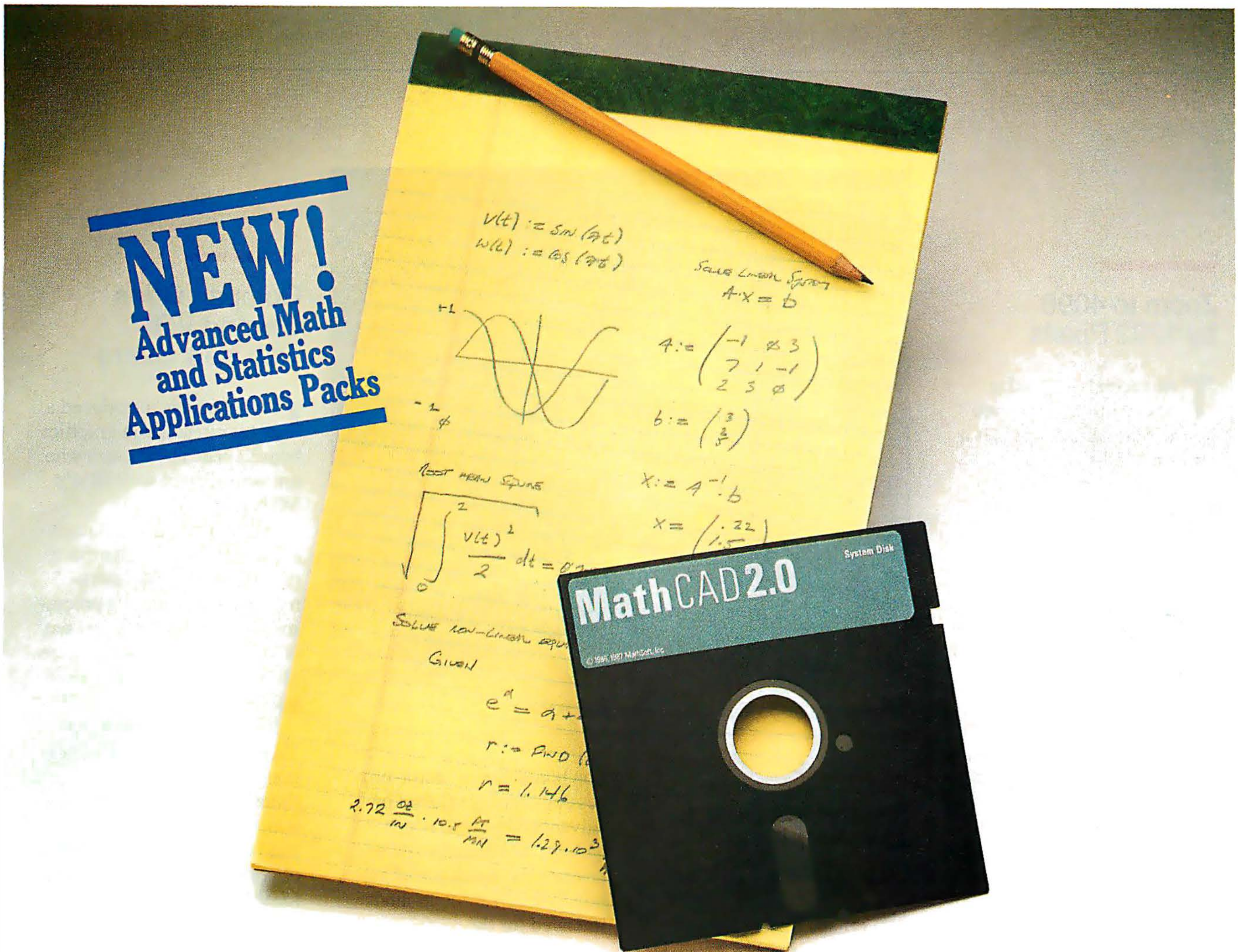
Voice Navigator consists of a hardware/software combination that includes an A/D converter and voice recognition software. The hardware is contained in a 9-inch-square box that plugs into the Mac's SCSI port.

The system comes with a built-in microphone, speaker, and sound controls, and it can also be used with virtually any external microphone/headset combination. On the software side, the Voice Navigator can be used as a desk accessory or INIT file so that voice control is always available.

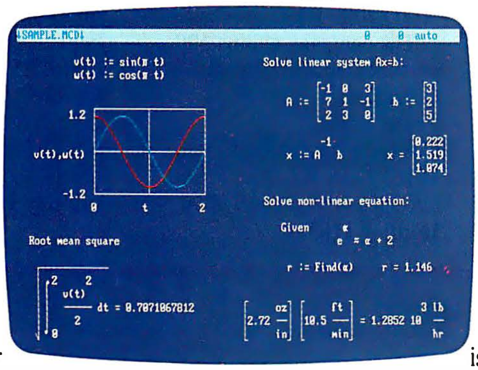
You can control the mouse cursor or any command in any application using the Voice Navigator—to control a HyperCard Japanese "language lab" application, for example. The Voice Navigator can also be used with Apple's MacroMaker.

A telecommunications option for later introduction involves a modem control so you can call up your Mac and tell it what to do.
Price: $999.
Contact: Articulate Systems, Inc., 99 Erie St., Cambridge, MA 02139, (617) 876-5236.
Inquiry 1158.

continued



Your pad or ours?



If you perform calculations, the answer is obvious.

MathCAD 2.0.

It's everything you appreciate about working on a scratchpad—simple, free-form math—and more. More speed. More accuracy. More flexibility.

Just define your variables and enter your formulas anywhere on the screen. MathCAD formats your equations as they're typed. Instantly calculates the results. And displays them exactly as you're used to seeing them—in real math notation, as numbers, tables or graphs.

MathCAD is more than an equation solver. Like a scratchpad, it allows you to add text anywhere to support your work, and see and record every step. You can try an unlimited number of what-ifs. And print your entire calculation as an integrated document that anyone can understand.

Plus, MathCAD is loaded with powerful built-in features. In addition to the usual trigonometric and exponential functions, it includes built-in statistical functions, cubic splines, Fourier transforms, and more. It also handles complex numbers and unit conversions in a completely transparent way.

Yet, MathCAD is so easy to learn, you'll be using its full power an hour after you begin.

What more could you ask for? How about two new applications packs to increase your productivity?

The **Advanced Math Applications Pack** includes 16 applications like eigenvalues and eigenvectors of a symmetric matrix, solutions of differential equations, and polynomial least-squares fit.

The **Statistics Applications Pack** lets you perform 20 standard statistical routines such as multiple linear regression, combinations and permutations, finding the median, simulating a queue, frequency distributions, and much more.

MathCAD lets you perform calculations in a way that's faster, more natural, and less error-prone than the way you're doing them now—whether you use a calculator, a spreadsheet, or programs you write yourself. So come on over to MathCAD and join 45,000 enthusiastic users.

For more information, contact your dealer or call **1-800-MATHCAD** (In MA: 617-577-1017).

Requires IBM PC® or compatible, 512KB RAM, graphics card.

IBM PC® International Business Machines Corporation.
MathCAD® MathSoft, Inc.

MathCAD®

MathSoft, Inc., One Kendall Sq., Cambridge, MA 02139

Circle 165 on Reader Service Card

Zoom to 4096 by 1792 Pixels

The second-generation Spectrum/8 video card for the Mac SE/30 provides a 1024- by 768-pixel display with pan and zoom features that allow you to see a part of the screen at a resolution of 4096 by 1792 pixels.

That resolution is designed with 1 bit of information corresponding to 1 pixel on the screen. At 2 bits per pixel, you can get up to four colors at a resolution of up to 2048 by 1792 pixels. At 4 bits per pixel, you rely on 16 colors and 2048 by 896 pixels. And at 8 bits per pixel, you get 256 colors and a resolution of 1024 by 896 pixels. Output can be color, gray-scale, or National Television System Committee–standard RGB.

The Mac SE/30 has an 030 Direct Slot connected directly to the 68030 microprocessor. The slot supports a 32-bit data and address bus and provides access to 32-bit ROM routines.

The Spectrum/8 will work with SuperMac, Apple, NEC MultiSync, and compatible monitors.

Price: $1895.

Contact: SuperMac Technology, 485 Potrero Ave., Sunnyvale, CA 94086, (408) 245-2202.

Inquiry 1162.



The Spectrum/8 video card zooms and pans.

RasterOps Board Aims to Make QuickDraw Quicker

Perhaps the biggest criticism of the Macintosh II as a potential engineering workstation is its graphics performance. For this reason, RasterOps Corp. has introduced the ColorBoard 118, a graphics accelerator board that, according to the company, can run applications up to 60 times faster than standard QuickDraw. (QuickDraw is a toolbox of routines for drawing graphics primitives; it's driven by the Mac's 68020 processor.)

RasterOps' 8-bit acceleration board uses a vector-processing chip, developed by Advanced Micro Devices (AMD), to intercept and accelerate the execution of certain QuickDraw commands intended for the 68020.

RasterOps' high-speed processing circuit, which incorporates the AMD chip, is called the Quad Pixel Dataflow Manager (QPDM). The company plans to implement it on its future boards using an AMD 2000 RISC processor.

The company claims 100 percent compatibility with QuickDraw.

Price: $3195.

Contact: RasterOps Corp., 10161 Bubb Rd., Cupertino, CA 95014, (408) 446-4090.

Inquiry 1163.

Compaq Goes Beyond VGA with New Board

Compaq has introduced a high-resolution graphics board aimed at PC users who are not satisfied with IBM's VGA resolution.

The new Advanced Graphics 1024 Board, built around the 50-MHz Texas Instruments 34010 graphics processor, can display 16 colors out of a palette of 16 million at resolutions of up to 1024 by 768 pixels.

With special drivers, the 1024 boosts AutoCAD operations by as much as five times compared to a VGA system, Compaq claims. Compaq is working with a number of vendors to develop drivers for the new graphics system, including CADKEY, Evolution Computing, and Graphic Software Systems. The board will work with many high-resolution monitors.

An optional 512K-byte memory board adds the capability to display 256 colors simultaneously.

Price: $1499; memory board, $599.

Contact: Compaq Computer Corp., 20555 FM 149, P.O. Box 692000, Houston, TX 77269, (713) 370-0670.

Inquiry 1164.

continued

Dictate to Your 80386 with Dragon Systems' Board

DragonDictate is an AT-compatible board that turns your 80386-based system into a large-vocabulary dictation machine. And for the first time, Dragon Systems says, you don't have to be specially trained to use it.

DragonDictate is based on the DragonWriter speech recognition system. Even with a 5000-word vocabulary, DragonWriter lets you dictate at near real-time rates.

The control and display interface is the key to its ease of use, Dragon Systems says. When a new word is spoken, the system relies on abbreviated keyboard entries to enter text. As it builds the acoustic models of the vocabulary, it shifts to real-time speech recognition to accelerate text entry. The interface controls the display of most likely words from the dictionary and the active vocabulary. It also places the voice- or keyboard-selected word into the text of the document.

You need an 8-bit slot, a 1.2-megabyte 5¼-inch floppy disk drive, a 40-megabyte hard disk drive, 640K bytes of system RAM, a half-megabyte of expanded memory, and 4 megabytes of extended memory.

The board also comes with software, a headset microphone, and an instructional VHS videotape.

Price: DragonDictate, $9000; DragonWriter, $4500.

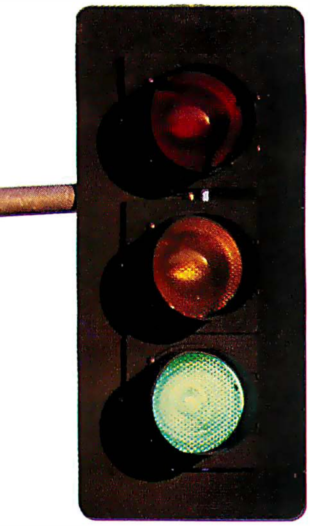
Contact: Dragon Systems, Inc., 90 Bridge St., Newton, MA 02158, (617) 965-5200.

Inquiry 1165.

Pull out all the stops

Turbo C® Professional is the *only* production-quality C compiler with a completely integrated environment.

Everything you need—*all* the tools—are *included* in this environment, so you never waste time stopping, starting, and switching between tools.



And you're not forced into trade-offs between high-productivity programming and small, fast, reliable code. Instead you get the fastest and the best of both worlds.

There's tight integration between editor, compiler, linker, and debugger that lets you race through your program with a fast edit/compile/run/debug cycle.

Only Turbo C Professional gets it all together

Now everything you need to write *and debug* production-quality, optimized code in *both* C and Assembly language is all yours in one package.



With Turbo C Professional you get:

- Turbo C 2.0 with its own integrated development environment—Compiler, Editor, Debugger, and Linker.
- Plus a separate command-line C Compiler
- Turbo Assembler®—a complete Macro Assembler that's more compatible with MASM than MASM is with itself.
- And the new source-level Turbo Debugger® that lets you debug *any size program*. Turbo C Professional has it all.

Turbo C 2.0	Turbo Assembler	Turbo Debugger
■ Compiles over 16,000 lines per minute ■ Hypertext online Help ■ Supports inline assembly ■ All six memory models supported ■ More than 450 library functions	■ Assembles up to 48,000 lines per minute ■ Compatible with MASM 4.0, 5.0, 5.1 ■ Full 386 support ■ Assembles multiple files	■ Debug any size program ■ Browse through structures with data debugging ■ Set conditional breakpoints, break on memory access ■ Stop, run code, log expressions ■ 386 ICE capabilities

Code: MC01

Turbo Debugger is a winner

Turbo Debugger won *PC Magazine*'s most recent Award for Technical Excellence, and here's what they said:

"Everyone who's tried the Turbo Debugger agrees. It wins the (development tool) category's award for Technical Excellence hands down. The user interface is simple yet elegant; the program works the way programmers want to work. Yet again, Borland has advanced the state of the art in an eminently useful way."

Bill Machrone, Editor-in-Chief, *PC Magazine*

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BORLAND





Plastic Optical-Fiber LAN Eases Installation Hassles

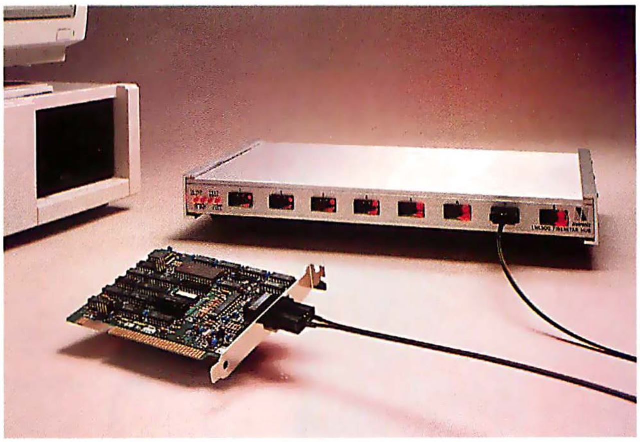
The Fiberstar PC network, the first commercially available plastic optical-fiber LAN, couples the installation ease of twisted-pair cabling with some of the communications advantages normally associated with glass optical fiber.

This takes plastic optical fiber beyond the realm of illumination of automotive instrumentation and into the office. At about $1000 per node, the 2-Mbps Fiberstar PC network makes plastic fiber a cost-effective alternative to twisted-pair copper wiring for local-area networking all the way to the desktop. And it brings with it glass fiber's often-touted advantage of immunity to electromagnetic interference.

Installation hassles are almost nonexistent with the Fiberstar PC LAN. This is because the Mitsubishi Rayon-manufactured optical fiber that Netronix uses is roughly 16 times the diameter of the glass optical fiber used in LANs. The plastic fiber is also less expensive and tougher than glass, which cannot be wound tighter than about a foot in diameter without degrading the signal or breaking the glass.

Installing and terminating glass optical fiber has always been the domain of telephone company technicians, who are said to use the expertise of an electrician and the precision and instruments of a jewel cutter. The plastic optical fiber used here, however, can easily be installed by the average office worker.

There's no need to polish the end of plastic fiber, and the plastic connector (by Amp, Inc.) simply snaps into its place on the XT-compatible add-in cards in your computer and on the Netronix networking hub.



Fiberstar, the plastic optical-fiber LAN from Netronix.

Each add-in card includes a 650-nanometer LED source and a positive-intrinsic-negative photodiode receiver. Optional cards conform to the TCP/IP.

The 16-port Fiberstar active hub is configured with 650-nm LEDs for plastic optical-fiber transmission distances of up to 500 feet, with 850-nm LEDs for glass optical fiber for transmission up to 5000 feet, or with combinations of different LEDs for the different media. (Active hubs have repeaters; passive hubs simply switch the signals.) In a star configuration, multiple hubs can support up to 240 nodes.

Through Netronix bridges and broadband adapters, Fiberstar PC hubs can hook into standard baseband networks like Ethernet and StarLAN, and into standard broadband networks as well.

Price: Card, $595; card with TCP/IP package, $895; 16-port hub, $2195.
Contact: Netronix, 1372 North McDowell Blvd., Petaluma, CA 94952, (707) 762-2703.
Inquiry 1159.

Sync Your PC with Telecommunications

The Network Access Controller from Sync Research gives many types of terminals a 64-kbps clear channel for data transfer. Standard support is available for PC and other asynchronous (including asynchronous X.29 hosts) and synchronous devices. A 3270 emulator is included to allow your PC to emulate 3270 terminals, both bisynchronous and System Network Architecture. (SNA is the set of specifications governing IBM networks; it's analogous to the Open Systems Interconnection reference model.)

About the only networking protocol left is TCP/IP, commonly used for Ethernet LANs, and Sync Research says that it plans to upgrade the Network Access Controller for TCP/IP functionality next.

The 64-kbps channel is possible through the X.25-standard packet-switched network.

The enabling device within the controller is a packet assembler/disassembler (PAD) that assembles packets of data for transmission with other packets on the X.25 telecommunications infrastructure. (Voice is carried through the same infrastructure but is not compressed into packets.)

Unlike the PAD modem recently introduced by Hayes, the Network Access Controller works only with leased telecommunications lines, not with dial-up, circuit-switched lines. That means you must lease the line from your telephone company at a premium price. But because you'll own that connection, there's no need to dial a number, and you'll never get the standard holiday message, "All circuits are busy; please try your call again."

Each Network Access Controller supports up to eight simultaneous sessions per terminal, and the standard Network Access Controller has four terminal ports. A separate control unit (available from several vendors) gives you multidrop capabilities with bisynchronous and SNA terminals for as many as 32 terminals per session. Based on the number of sessions and the multidrop capabilities, a Sync Research spokesperson estimated that between 40 and 100 people will use a single Network Access Controller simultaneously.

To tie it all together, you'll need to add network management hardware and software from Sync Research.

The network management hardware consists of an 80286-based machine with 2 megabytes of RAM, a 71-megabyte hard disk drive, a port for Sync's proprietary AT-compatible communications board, and an asynchronous terminal. The 80286-based machine runs Xenix and the Sync software.

Price: $5880; four-port expansion, $2500 each; network management hardware, $12,500; software, including Xenix, $16,240.
Contact: Synch Research, 13891 Newport Ave., Tustin, CA 92680, (714) 669-8020.
Inquiry 1160.

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The computer interface is RS-232C. There's a parallel printer port, and the JE680 supports standard, intelligent, and quick-pulse programming methods.

A pin-check function with pulse-reflection technology lets you examine individual pins. You can use up to 18 data formats, and the JE680 is compatible with many of the software packages written for other EPROM programmers. Or you can use the software option package—including Boolean conversion, autocompiling, and fuse map generation—for logic design applications.

After programming, you can use the JE680 to do an automatic self-test, an insertion and backward-device check, and other test functions.

Price: $1799.95; software, $29.95.

Contact: Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002, (415) 592-8097.

Inquiry 1166.



The JE680 Universal IC Programmer works for memory and logic devices.

EPROM Eraser Shields You from Shortwave UV Light

The EE128 EPROM Eraser uses a 4-watt, 254-nanometer ultraviolet light source to erase up to nine EPROMs in less than 30 minutes. But you won't get any UV exposure with the snaplock drawer and safety switch that help block the escape paths for these harmful rays. There's even a lamp-on indicator for extra protection.

Price: $79.95.

Contact: Ultra-Lum, Inc., 217 East Star of India Lane, Carson, CA 90746, (213) 324-2247.

Inquiry 1167.

Firmware Prototyping Made Easy

The Analogica-T is a software and hardware development tool designed for prototyping computer control interfaces to scientific instruments and industrial equipment. It looks like a full-length board for your PC (it's XT or AT compatible) and a hardware design unit that's just about the length and width of your briefcase.

An 8255-A provides 24 lines of parallel I/O, and switching allows address selections as required for such things as direct memory access and serial I/O.

Circuitry is mostly wire-wrap, Westcoast Technical & Hobby says, so you can make custom modifications. It also lowers the price for using printed circuit boards with copper on only the top and bottom layers.

Driver software is supplied in .EXE and .ASM formats on a 5¼-inch floppy disk drive. Executable 8088 code and an 8255-A driver are also included, as are source code skeletons.

The design board includes buffered system signals brought to terminal strips adjacent to four solderless breadboards.

Each kit comes with assembly instructions and schematics for installation in about 30 hours, depending on the options.

Price: $721; assembled and tested, $1203.

Contact: Westcoast Technical & Hobby, P.O. Box F110-415, Blaine, WA 98230; or call the headquarters in Surrey, BC, Canada at (604) 591-1624.

Inquiry 1168.

Mac Digitizing System Works in 3-D

Forget mice; forget touch panels. At the MacWorld Expo, Mira Imaging introduced a digitizing system that uses three dimensions. The new HyperSpace system consists of a small table that can detect the position of a pen-like stylus in three-dimensional space. Company representatives demonstrated the system by digitizing a bust of an Egyptian pharaoh.

You place the stylus on a point on the surface of the bust and then press the mouse button. A group of electromagnetic sensors located in a small table under the bust then determines where the stylus is located and passes the information to the Macintosh.

Once a sufficient number of points is determined, the System software can then group the points into triangular planes to create a surface. The software can then soften this jagged surface into a smoother one. Once the surface has been generated, you can shade the surface and change the angle of lighting by moving the stylus.

The company claims that the system has a resolution of 0.03 inch at a distance of 15 inches. As expected, the resolution gets worse with increasing distance. In addition to the *x*, *y*, and *z* coordinates of the stylus, the system can also measure its pitch, yaw, and roll. Because it uses electromagnetic waves, the HyperSpace system can be used only with nonmetallic models.

Price: $5300.

Contact: Mira Imaging, Inc., 969 Logan Ave., Salt Lake City, UT 84105, (801) 485-6765.

Inquiry 1169.

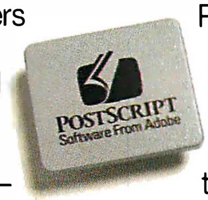
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Memory (RAM)	1MB Expandable to 16MB	640K Expandable to 8MB	1MB Expandable to 14MB	1MB Expandable to 13MB	1MB Expandable to 14MB	1MB Expandable to 16MB
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For more information on the FlexCache Z-Series or the name of your local authorized ALR reseller please call:

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Graphics Software Engineering

Using the MetaWindow graphics driver from MetaGraphics, Turbo Meta-Menu provides a user interface for any graphics application program with Turbo Pascal versions 4 and 5. You can create menus, pop-up messages, button menus, and more.

The Turbo Meta-Menu utilities package consists of a library with over 70 procedures that help you create menus. Two additional programs are also included: CurEdit is an icon editor, and MakeMenu is a Turbo Pascal code generator.

To run the program, you need MetaWindow graphics, an IBM PC with a video graphics adapter, a mouse, and a hard disk drive.

Price: $149; MetaWindow, $95; source code, $75.

Contact: Island Systems, 7 Mountain Rd., Burlington, MA 01803, (617) 273-0421.

Inquiry 1120.

FORTRAN Text Editor for the Mac

Developing FORTRAN codes and models on the Macintosh has been difficult in the past due to the cumbersome editors. FREDitor is a text editor with the standard features along with some special functions, such as multiple windows, global regular-expression parser (GREP) search and replace, custom autowrap, on-screen column markers, and the ability to generate tables for export to spreadsheets.

FREDitor was developed at Battelle's Pacific Northwest Laboratories and is being published and marketed by TechAlliance (formerly A.P.P.L.E. Co-op).

FREDitor runs on any Macintosh, according to TechAlliance.

Price: $79.95.

Contact: TechAlliance, 290 Southwest 43rd St., Renton, WA 98055, (206) 251-5222.

Inquiry 1121.

Modula-2 on the Mac

The MetCom Modula-2 integrated programming environment for the Mac includes a multiwindow text editor, a one-pass compiler, and an interactive debugger.

The MetCom Editor uses information from the compiler to show various positions in the source program where syntactic errors occur. You can also shift blocks of text, indent text as you enter it, or display windows as tiles or stacks. You can open multiple windows and handle files of any size.

The one-pass compiler generates native code for the 68000/68020 processors, and the code needs no explicit linking, according to the manufacturer. Each compilation produces two files: an object file used by the linker for execution, and a reference file used by the source-level debugger. A dialog box also lets you know how the compilation process is going.

You can view the execution environment at run time with the Runtime Examiner. If an error occurs, the debugger is called and displays several windows that show the source statements being executed, the modules and procedures called, and the values of module and procedure variables, as well as the addresses of the various loaded modules.

A variety of libraries and Macintosh interface modules is included with the program.

MetCom Modula-2 runs on the Mac Plus, SE, and II with System version 4.1 or higher and two 800K-byte floppy disk drives. A hard disk drive is recommended but not required.

Price: $245.

Contact: Metropolis Computer Networks, Inc., The Trimex Building, Route 11, Mooers, NY 12958, (514) 866-4776.

Inquiry 1124.

Adding Graphics to Unix the Convenient Way

The Convenience Plus Unix front end is a graphics interface for Unix from SoftScience. The program lets you perform file management, operating-system commands, and other administrative functions. It offers you a graphical tree display of your stored files, which you can traverse with arrow keys or a mouse.

You can call up windows to display and interact with a graphical image of file storage. The window can also list files or running applications. Other features include a hexadecimal editor/viewer, a search function, and utilities for manipulating files in groups or individually. You can also move files across directories, and you can create and delete directories with the interface.

The program is compatible with Sun, AT&T, and other Unix systems.

Price: $399.

Contact: SoftScience Corp., P.O. Box 42905, Tucson, AZ 85733, (602) 326-4679.

Inquiry 1122.

Forth in the Public Domain

To encourage programmers to use Forth to develop large applications, the Silicon Valley Chapter of the Forth Interest Group has donated F-PC 2.25 to the public domain. The Forth development environment is derived from F83, an earlier public domain version of Forth.

F-PC 2.25 comes on four 360K-byte disks with most files archived. The object code takes 400K bytes of RAM, while the source code and documentation take up about 3 megabytes of disk space.

Some of the features offered by F-PC 2.25 include a command-line interpreter, a high-level procedure compiler/decompiler, an 8086/87 assembler/disassembler, a multitasker, a single-step debugger, core image dump, source code listing and indexing, text searching through files, a turnkey application generator, and a meta-compiler for system regeneration. A collection of applications includes floating-point packages, object-oriented procedures, databases, graphics, mathematics, games, music programs, and more.

The program runs on the IBM PC. A graphics card and hard disk drive are recommended.

Price: $25; user's manual, $20; technical reference manual, $30.

Contact: Offete Enterprises, Inc., 1306 South B St., San Mateo, CA 94402, (415) 574-8250.

Inquiry 1123.

continued



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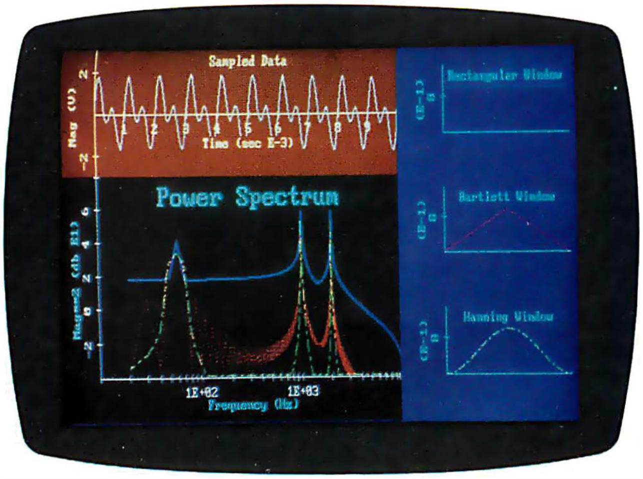
PC Data Master, a DOS environment for signal processing and display, has been enhanced with separately compiled modules for systems with and without a math coprocessor, a multisignal plot utility, and an enhanced DOS shell.

The program combines graphics routines, real- and complex-data-file math routines, digital signal processing utilities, test-data generation routines, data sampling routines, and binary data pipes to create a DOS-based DSP system.

Most graphics boards are supported, and you can integrate data-analysis functions into the program using most compilers or assemblers compatible with DOS 2.0 or higher.

The shell that is at the heart of PC Data Master lets you implement independent DOS console and graphics screen windows. When the shell is active, you can interact with DOS application routines in the console window without disturbing screen graphics, according to the manufacturer. The shell also provides binary data pipes for linking data-processing steps, implemented as independent executable files into multistage data transformations. The pipes are distinct from the DOS pipes and don't affect the standard input and output logical devices, according to Durham Technical Images.

A waveform module is also included with PC Data Master. You can display individual or multiple data files using the plot system's auto-configuration capabilities. You can use pop-up menus and forms, and you can adjust each plot on the display for size, placement, colors, titles, labels, assignment of data files and channels to axes, and more. You can also store display templates with display designs, and you can print hard copies of data displays in portrait and landscape orientation using dot-matrix or laser printers.



PC Data Master 2.0 is an enhanced DOS environment for signal processing and display.

Version 2.0 comes with an augmented set of DSP utility modules. Operations include forward and inverse fast-Fourier-transform and fast-Hartley-transform routines, convolution, correlation, window generation, FIR filter design, and test-data generation.

You can implement many multistage transformations by combining these basic operations with data-file math routines in data pipes, according to Durham Technical Images. Data acquisition modules for MetraByte analog input products are also included, and you can integrate routines for other analog I/O products.

PC Data Master 2.0 runs on the IBM PC with 256K bytes of RAM and DOS 2.0 or higher. A hard disk drive and a math coprocessor are recommended. Shells are provided for CGA, Hercules, AT&T, EGA, and VGA graphics.

Price: $135.

Contact: Durham Technical Images, P.O. Box 72, Durham, NH 03824, (603) 868-5774.

Inquiry 1126.

Stats Packs Added to MathCAD

Two recently released application packs for MathCAD 2.0 cover tests and estimation, and modeling and simulation, respectively. MathCAD lets you use a PC like a scratch pad, according to MathSoft. You can enter and calculate equations, create plots, and enter and edit text. The program also lets you integrate math, text, and graphics on- and off-screen.

The Tests and Estimation pack lets you implement standard test procedures, create your own test procedure, simulate experiments, and model data from within your MathCAD document. A set of standard routines including parametric and nonparametric techniques is included.

The Modeling and Simulation pack includes techniques for modeling data and carrying out simple Monte Carlo simulations. Each pack contains 16 standard procedures.

These application packs are the second and third in a series for use with MathCAD. The first in the series was the Advanced Math Applications Pack. You can purchase the packs separately or bundled together with MathCAD 2.0.

MathCAD 2.0 runs on the IBM PC with at least 512K bytes of RAM and DOS 2.0 or higher. The company recommends a math coprocessor.

Price: Statistics I: Tests and Estimation, $59; Statistics II: Modeling and Simulation, $69; I and II, $99; MathCAD 2.0, $349.

Contact: MathSoft, Inc., One Kendall Sq., Cambridge, MA 02139, (800) 628-4223; in Massachusetts, (617) 577-1017.

Inquiry 1128.

continued

Building Chemical Structures on the Mac

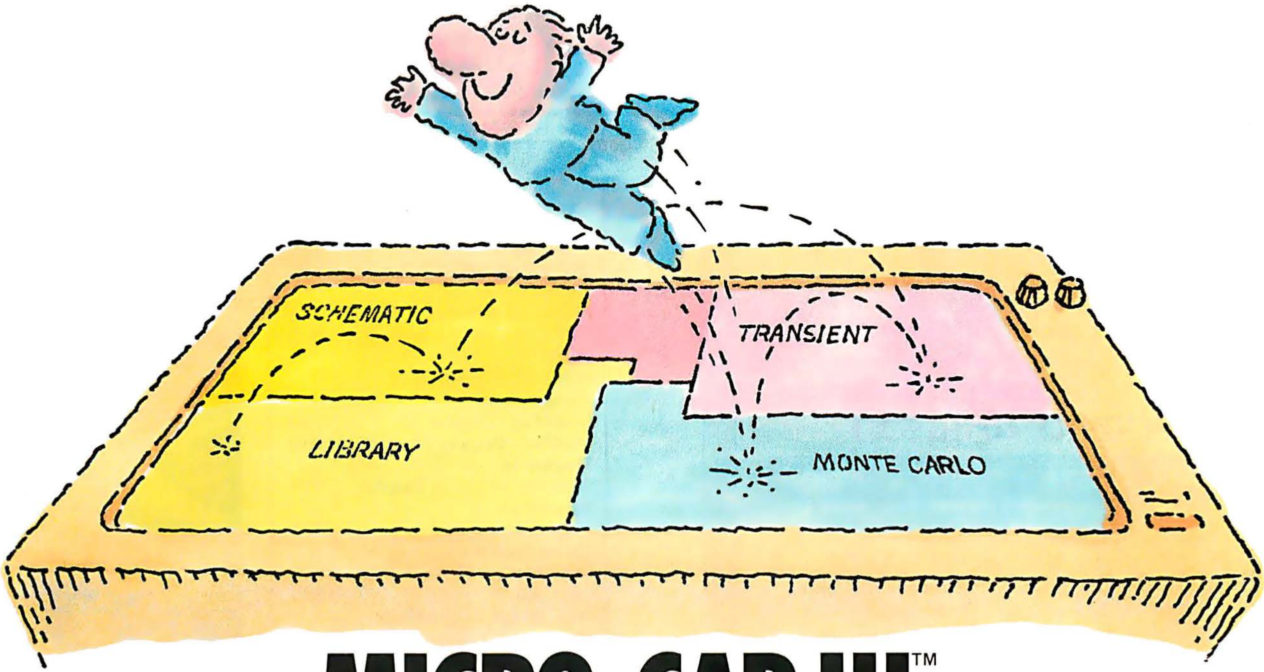
Chemists involved in searching STN International's chemical structure database may find that ChemConnection simplifies the process of constructing a chemical structure. You can draw a query structure offline using the same drawing capabilities as in the ChemIntosh Desk Accessory, according to SoftShell. You also don't need to know all the structure-generation commands used by the Chemical Abstracts Service, SoftShell reports.

ChemConnection runs on the Macintosh with at least 1 megabyte of RAM and a hard disk drive.

Price: $395.

Contact: SoftShell International, Ltd., 2004 North 12th St., Grand Junction, CO 81501, (303) 242-7502.

Inquiry 1125.



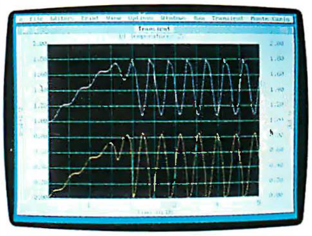
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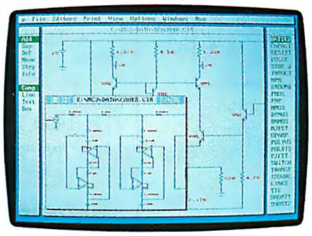
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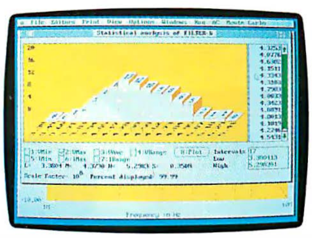
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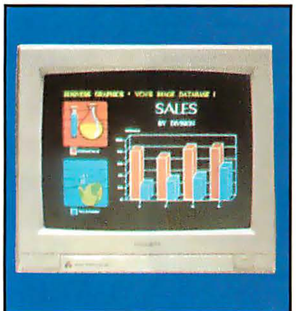
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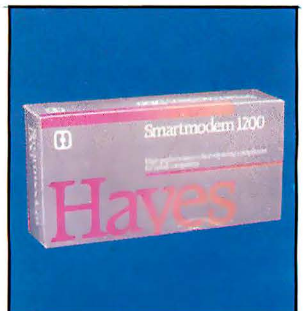
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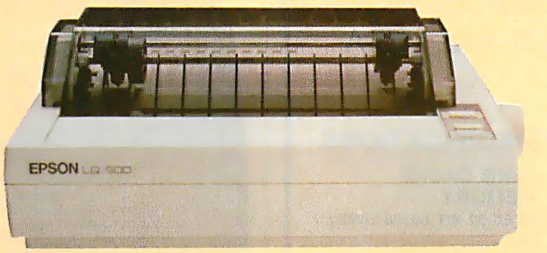
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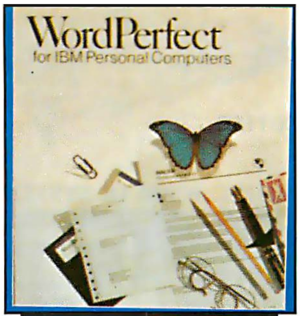
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A104

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SOFTWARE • BUSINESS



SYZYGY lets you manage multiple projects in real time.

Processing Words the Mac Way

Paragon has gone one step further with its text editor QUED/M and created Nisus, a word processing program for the Macintosh.

The company says that the word processor stores text and formatting separately, so you can open and edit Nisus documents in any program or desk accessory.

In addition, the program offers a feature called Zap Gremlins, which deletes any surplus characters that might result from importing text from another operating system.

The program's search and replace makes use of GREP, and its find and replace facility lets you search by style and fonts. An Easy-GREP facility features a pull-down menu.

Ten clipboards are included in the program, each of which you can edit, append to, save, or print. An undo facility is included, as is a page-preview feature.

Paragon claims you can have any number of files open at once, and you can tile or stack windows. The program's graphics capabilities let you draw graphics directly into text, place a picture over text, or have text wrap around it. You can use the Clipboard or other applications to draw or paste graphics.

Nisus runs on the Macintosh with 1 megabyte of RAM (2 megabytes under MultiFinder). It supports the LaserWriter and the Imagewriter printers.

Price: $395.

Contact: Paragon Concepts, Inc., 4954 Sun Valley Rd., Del Mar, CA 92014, (619) 481-1477.

Inquiry 1130.

Tools for the Legal Trade

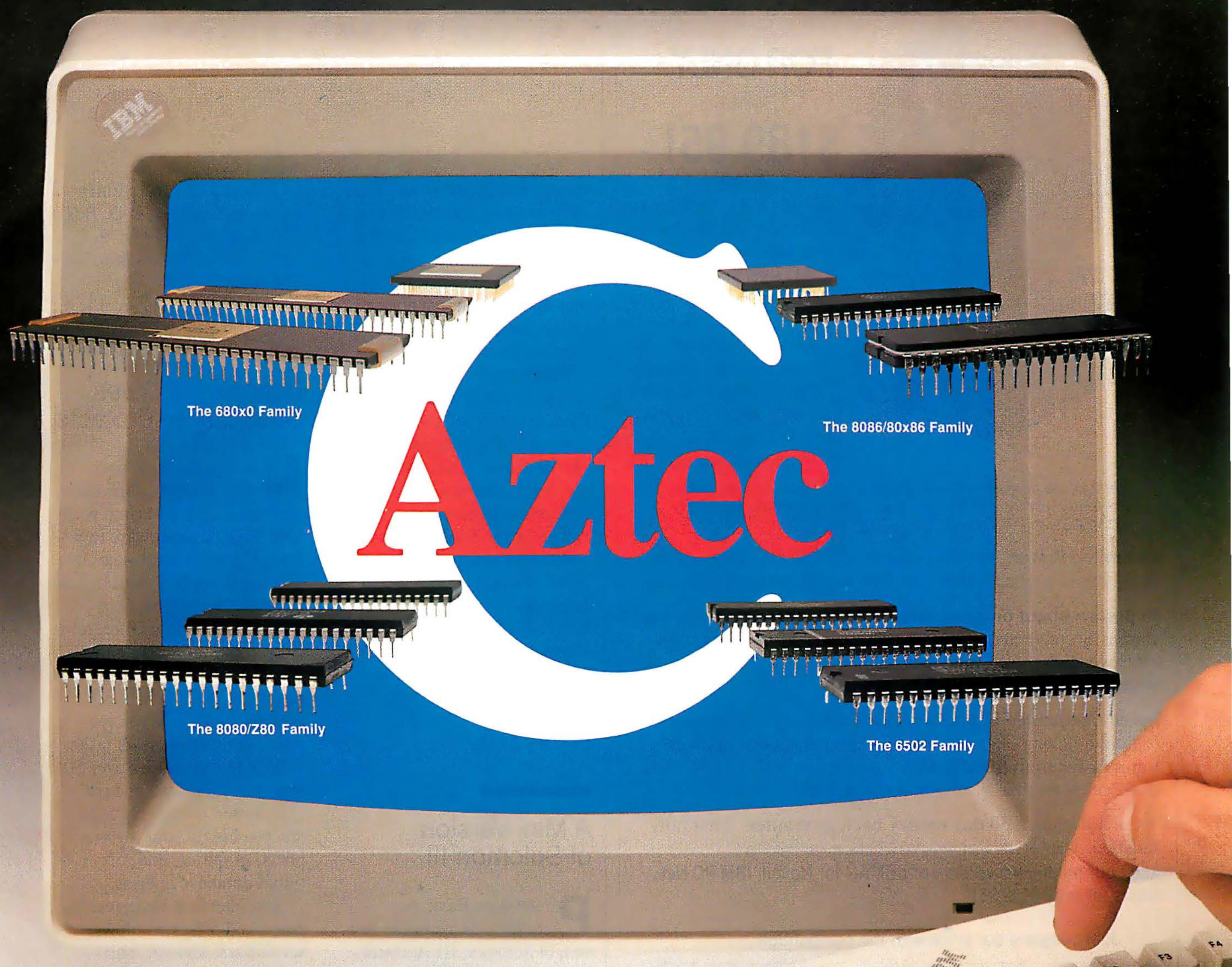
CompareRite, CiteRite II, and FullAuthority, three of Jurisoft's productivity programs, are now grouped together in one package called The Legal Toolbox.

CompareRite is a redlining program that lets you compare two versions of a document; it creates a redlined draft for you, showing the differences between the two.

CiteRite II is a citation program that checks Bluebook and California-style citations without requiring text markers to indicate where the citations

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occur. The program automatically locates citations in legal documents, checks them for proper form, and reports any errors. You can operate it as a pop-up program that checks citations from within your word processor.

FullAuthority looks for citations in briefs and arranges them to create a formatted table of authorities. It lets you choose to sort them into statute, book, law review, or other citation categories.

The Legal Toolbox runs on the IBM PC with 210K bytes of RAM and DOS 2.0 or higher.

Price: $365.
Contact: Jurisoft, Inc., 763 Massachusetts Ave., Cambridge, MA 02139, (617) 864-6151.
Inquiry 1133.

A Mini Version of Solomon III

ProfitWise Basic Accounting is a smaller version of Solomon III Accounting Software for businesses with annual revenues of less than $500,000. The major difference between the two programs is the limitation placed on the number of transactions that ProfitWise will handle. The databases of both systems are compatible, so you can upgrade to Solomon III, the company reports.

ProfitWise includes general ledger, accounts payable and receivable, payroll, invoicing, fixed assets, and address modules. Add-on modules include inventory and job costing, and report and graph designer.

The program runs on the IBM PC with 512K bytes of RAM, 10 megabytes of hard disk storage, and DOS 3.1 or higher. You'll need 576K bytes for the report designer.

Price: $229; add-on modules, $229 each.
Contact: TLB, Inc., Entry Products Division, P.O. Box 414, Findlay, OH 45839, (800) 777-0521; in Ohio, (419) 424-0422.
Inquiry 1131.

Groupware Gives Structure to Projects

Manage multiple projects, people, schedules, and budgets in real time with SYZYGY, a groupware tool from Information Research. The program lets you delegate assignments and monitor workgroups with its hierarchical activity tool. Using the Gantt chart tool, you can show due dates and status of all your projects, and you can zoom in on lower-level tasks.

SYZYGY includes over 50 report capabilities, and the SQL-based query language lets you create your own reports, graphics, and relational database queries.

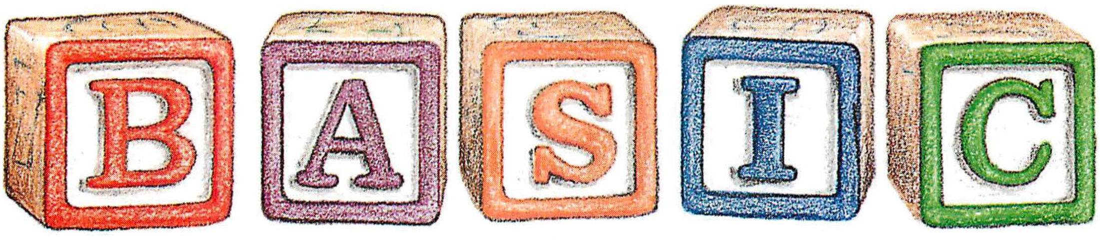
The interface is object-oriented and offers windows, scroll bars, and cut, paste, and copy tools. SYZYGY files are compatible with DIR, SYLK, XLS, WKS, and WK1 files.

The program runs on the IBM PC with 512K bytes of RAM. It supports monochrome, Hercules, CGA, EGA, and VGA monitors. A NetBIOS-compatible network version is available.

Price: $395; network version for two users, $595; three to 10 users, $995; 11 to 25 users, $1495; unlimited users, $1995.
Contact: Information Research Corp., 2421 Ivy Rd., Charlottesville, VA 22901, (800) 368-3542; in Virginia, (804) 979-8191.
Inquiry 1132.

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Whether you are a professional or a novice, PROBAS will boost your BASIC in ways you never dreamt possible. PROBAS allows professionals to save time and work and lets novices write professional-quality programs quickly and easily. After all, how much is a few hundred hours of your time really worth?

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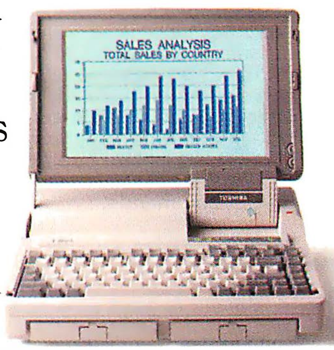
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Second, the T3100e, the successor to our most popular machine—the T3100/20. We've made it nearly two pounds lighter and a lot faster—we've even added expansion capabilities. About the only thing we didn't add was more size.



T1600: Battery-powered 286/12MHz, coprocessor socket, 20MB hard disk at 27msec, 1.44MB 3½" diskette drive, 1MB RAM expandable to 5MB, detachable backlit EGA compatible LCD, removable rechargeable battery pack.

Toshiba is the world leader in truly portable PCs and manufactures a complete line of high quality dot-matrix and laser printers. For more information call 1-800-457-7777. All Toshiba PCs are backed by the Exceptional Care program (no-cost enrollment required). IBM is a registered trademark of International Business Machines Corporation. Model T5200 has not been approved by the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased until the approval of FCC has been obtained.



And finally, the T5200, which has enough power to replace virtually any desktop PC.

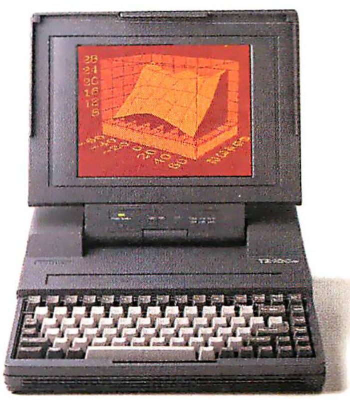
But we haven't just concentrated on power and portability. We've also constantly looked for ways to make our machines more durable, more reliable, and easier to use— down to the 800 number our customers can call for help with any technical question that might come up.

We figure that's what our users demand.

And it's by anticipating the growing needs of our users that we have continually found ways to make our machines weigh less and do more. So you can work wherever you want and however you want.

All of which might make it tempting for some people to abandon their desktop for the convenience of portability. Go ahead.

We've given you the power to do it.



T3100e: 12MHz 286 with 80287 coprocessor socket, internal half-length IBM slot, 20MB hard disk with 27 msec access, 1MB RAM expandable to 5MB, gas plasma display, 1.44MB 3½" diskette drive.

In Touch with Tomorrow

TOSHIBA

Toshiba America Inc., Information Systems Division

Circle 282 on Reader Service Card (DEALERS: 283)

SOFTWARE • CONNECTIVITY

Networked Decisions

Ashton-Tate's integrated software program, Framework, is now available in a network version. Framework III LAN supports five users and includes built-in E-mail, file locking with three file-sharing modes, and peripheral sharing.

Framework includes word processing, database, spreadsheet, business graphics, outlining, and E-mail facilities. The program uses the standard message format, Message Handling Service, developed by Action Technologies and Novell. This lets you communicate with other Framework III users as well as users of other software packages implementing the MHS message format. You can also send mail over phone lines from one LAN to another and from LANs to remote PCs, according to Ashton-Tate.

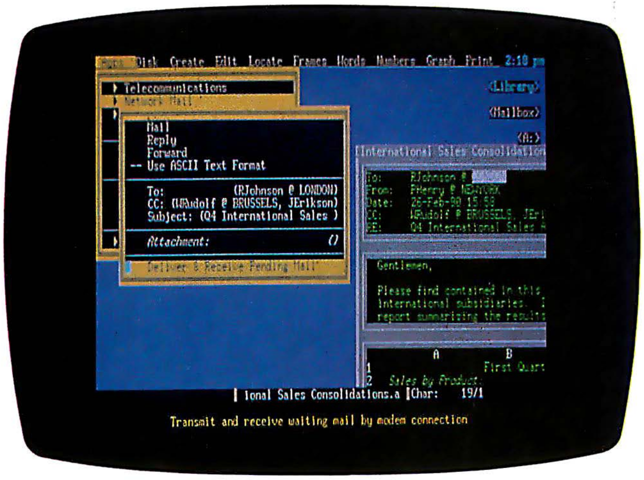
Framework III is available in a variety of international languages, and Ashton-Tate reports that the LAN version will be available in translated editions in the spring of 1989. All screens, menus, messages, spelling dictionaries, and documentation will appear in the local language. Optional disks with spelling checkers, hyphenation programs, and thesauri are available in German, French, British English, Italian, Dutch, Swedish, Spanish, Danish, Norwegian, and Portuguese.

Framework III LAN runs on the IBM PC with 640K bytes of RAM. It supports the following networks: Novell Advanced and SFT NetWare/286; IBM PC and Token Ring networks running IBM PC LAN; the 3Com 3+ Network; and the AT&T StarLAN.

Price: $995 for five users.

Contact: Ashton-Tate Corp., 20101 Hamilton Ave., Torrance, CA 90502, (213) 329-8000.

Inquiry 1136.



With Framework III LAN's E-mail, you can communicate with users of Framework III and other mail systems.

SOFTWARE • CAD AND GRAPHICS

First Solids Modeler for the Mac

With three-dimensional design and two-dimensional drafting capabilities, Infinite Graphics calls In-CAD the first true solids modeler for the Macintosh II. In-CAD is the first in the In-Vision family of programs for mechanical design, engineering, drafting, analysis, and manufacturing.

In-CAD combines constructive solid geometry capabilites with a WYSIWYG interface, so you can work with the modeler and see the changes take place as you make them. The program differentiates between material and voids, according to Infinite Graphics. Building-block primitives and Boolean operations are used to add and subtract material, and you can view models from any direction with hidden lines removed, shaded, or sectioned. The program also calculates area and mass/volume properties. In addition, you can modify any portion of the model, and the changes will be made automatically throughout the model.

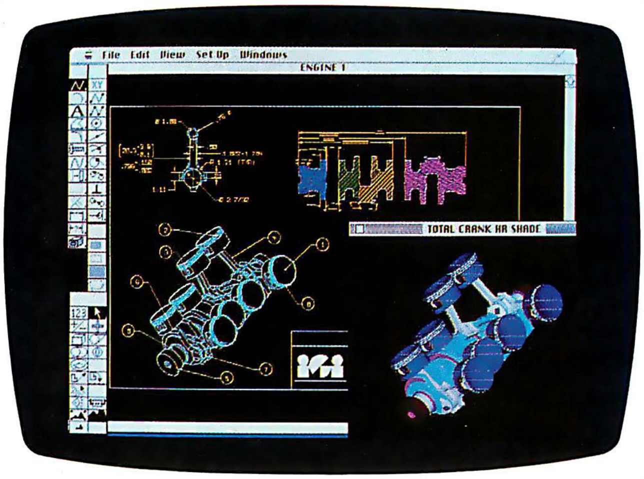
Other capabilities include dimensioning, splines, user-definable text fonts and cross-hatch patterns, full geometry creation and editing, subfigures for library parts and components, user-definable attributes and grouping, labeling with balloons and automatic incrementing, variable-width lines, and a programming language. The program also offers associative dimensioning with the ability to update dimensions that are related to a dimension that you've changed.

In-CAD runs on the Mac II. It features an Initial Graphics Exchange Specification translator for importing and exporting files between other CAD systems. A translator is also included for AutoCAD DXF files. The program supports Mac menus, desk accessories, and a windowing environment. You can also use a tablet or text commands.

Price: $1945.

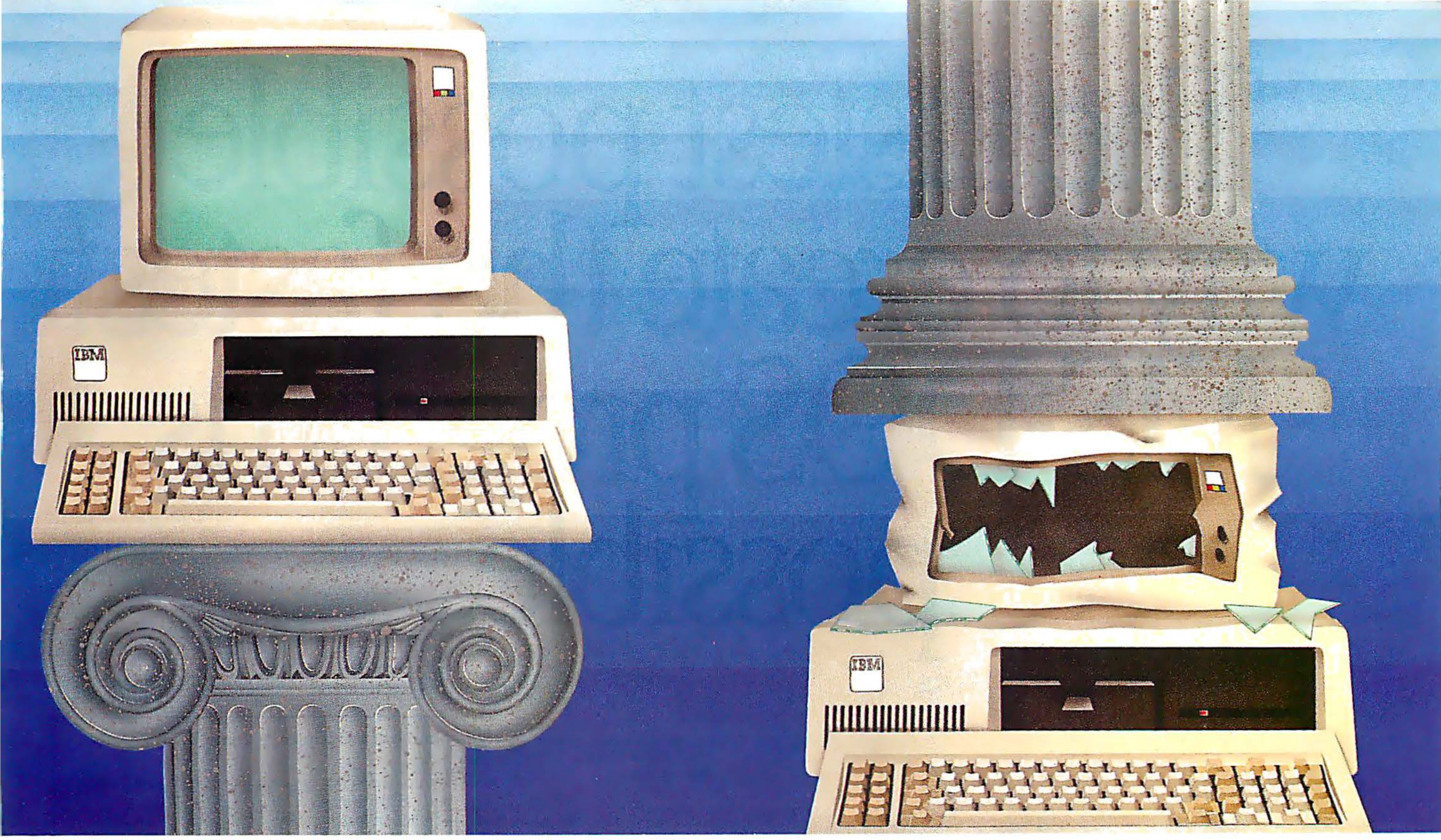
Contact: Infinite Graphics, Inc., 4611 East Lake St., Minneapolis, MN 55406, (612) 721-6283.

Inquiry 1137.



In-CAD gives the Mac three-dimensional design, two-dimensional drafting, and solids modeling capabilities.

continued



QNX® vs. UNIX OS/2

Architecture can make or break a computer system.

Don't make your systems bear the brunt of massive, monolithic monsters like Unix or OS/2. Instead, build your systems with QNX. The lean, efficient OS that's flexible enough to support any application.

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QNX, on the other hand, hums along using an efficient 150K of RAM, yet provides a powerful multiuser, multitasking, and integrated networking environment.

TRUE DISTRIBUTED PROCESSING. A QNX-based PC LAN lets any user share *any* resource on the network—programs, data, devices, even CPUs—without going through the bottleneck of a central file server. With QNX you get mainframe power at micro prices.

ADDED VALUE FOR VARS. QNX is flexible enough to run on *any mix of* PCs, ATs, PS/2s, with or without dumb terminals. Even diskless workstations are supported. So whether you start small or grow to mainframe proportions, you can easily build and maintain powerful, fault-tolerant systems without spending a fortune on hardware.

REALTIME PERFORMANCE. Only QNX combines the performance of a dedicated realtime executive with the convenience of a rich development environment that includes a host of utilities, C compiler, full-screen editor, symbolic debugger, and multiple full-screen windows.

DOS SUPPORT. For those who need their daily dose of DOS, QNX allows a DOS application to run as a single task on each PC on the network.

FREE TECHNICAL SUPPORT. While users of other operating systems have to cough up hefty fees for support, QNX developers enjoy *free* hotline support and *free* BBS access. You'll get prompt answers to your questions and you'll share ideas and insights with fellow developers in the QNX community.

It's time to make the move to QNX.

Circle 233 on Reader Service Card

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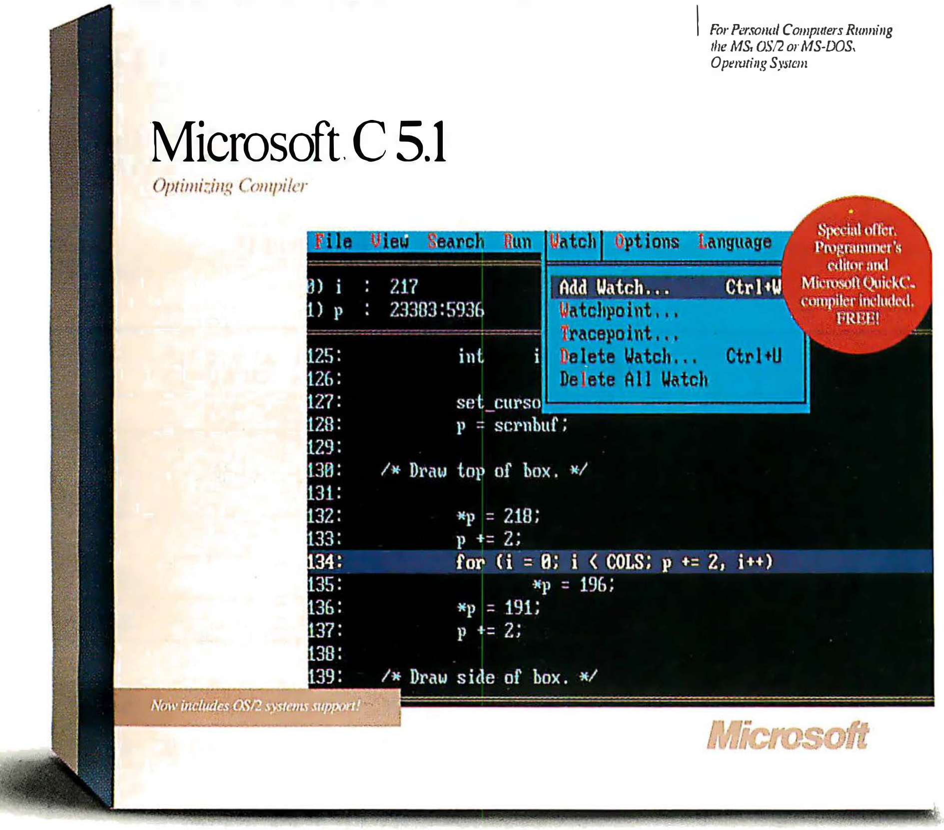
Multiuser	10 (32) serial terminals per PC (AT)
Multitasking	64 (150) tasks per PC (AT)
Networking	2.5 Megabit token passing. 255 PC's and/or AT's per network. Thousands of users per network.
Realtime	4,250 task switches/sec (AT).
Message Passing	Fast intertask communication across the network.
C Compiler	Standard Kernighan and Ritchie.
Flexibility	Single PC, networked PC's, single PC with terminals, networked PC's with terminals. No central servers. Full sharing of disks, devices and CPU's.
PC-DOS	PC-DOS runs as a QNX task.
Cost	From US $450. Runtime pricing available.

QNX

For further information or a free demonstration diskette, please telephone (613) 591-0931.

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Microsoft Editor is the first reconfigurable text editor for programmers that lets you develop under MS-DOS and MS OS/2. Under MS OS/2, multitasking lets you edit one file while you compile another, which cuts development time. You can even generate multiple compiles that report errors directly back into your source code.

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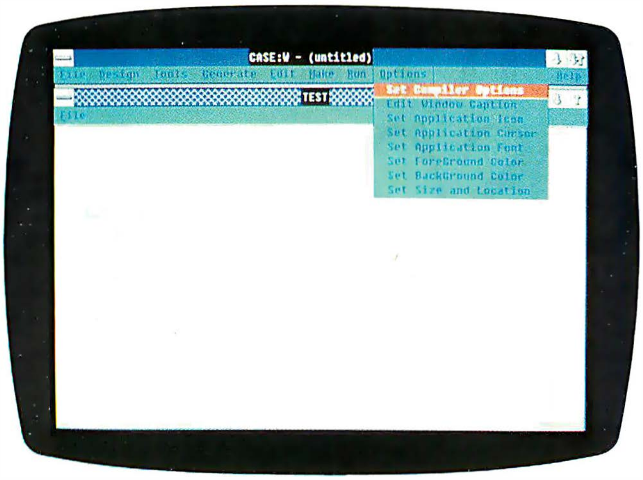
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Programming in the Microsoft Windows environment can be difficult and time-consuming because you spend your time writing event handlers and responding to Windows messages. A CASE tool from CASEWorks was designed to make your life a little easier. CASE:W does most of the Windows programming for you, letting you concentrate on the application-specific parts of the program, according to the manufacturer.

CASE:W is an expert system with a knowledge base of Windows code sets and production rules. A prototyper, or front end, is included, which lets you specify the characteristics you want for the program's main window and menu system. Then CASE:W automatically generates the program code files and make files.



CASE:W gives programmers easy access to the compiler command line.

The Windows controls that the program takes care of for you include menu bars, pop-up menus, and dialog boxes.

A Program Regeneration facility is included with the package. It carries forward any code you add from one generation of an application to the next.

CASEWorks also announced plans for a CASE tool for Presentation Manager.

CASE:W runs on 80286- or 80386-based machines with at least 2 megabytes of RAM and Windows. You must have the Microsoft Windows Software Development Kit, the Microsoft C Compiler version 5.0 or higher, a make utility and linker, and a DOS- or Windows-compatible text editor. The company also recommends Microsoft's CodeView debugger.
Price: $1495.
Contact: CASEWorks, Inc., One Dunwoody Park, Suite 130, Atlanta, GA 30338, (404) 399-6236.
Inquiry 1141.

continued



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Also, **.RTLink**'s easy-to-use Run Time Library feature lets you significantly reduce the amount of disk space needed for storage and shipping of your programs.

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When you consider the speed, power, versatility, and control features provided by **.RTLink** that are not available in any other linker, don't you think it's time you got a new linker?

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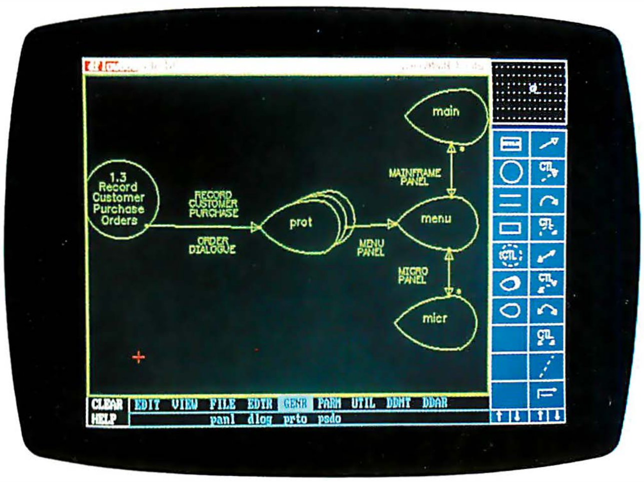
Circle 219 on Reader Service Card

Sylva Upgraded

Interactive screen prototyping and COBOL code generation have been added to the Sylva System Developer CASE tool, a program that automates analysis and design techniques.

The prototyping facility lets you paint screens and create dialogues that look and behave like an interactive system, according to Cadware. After you've approved of the prototype, you can quickly generate the COBOL screen-handling source code.

To run the Sylva System Developer, you need an IBM PC with DOS 3.0 or higher and at least 640K bytes of RAM. A mouse is recommended along with an EGA board.



Paint screens and create dialogues with Sylva's screen prototyping capability.

Price: $3495.
Contact: Cadware, Inc., 50 Fitch St., New Haven, CT 06515, (800) 223-9273; in Connecticut, (203) 387-1853.
Inquiry 1144.

MicroStep

MicroStep is a CASE tool that produces C source code and executable programs from your graphics specifications, according to SysCorp. The program features an interactive graphic design environment, automatic specification analysis, generation of executable code, and the production of technical documentation. You can use the program to generate PC applications or as a rapid prototyper.

The program features a mouse-driven interface.

MicroStep runs on the IBM PC with 640K bytes of RAM, DOS 3.1 or higher, a 20-megabyte hard disk drive, an EGA or Hercules card, and a mouse.

Price: $5000.
Contact: SysCorp International, 9420 Research Blvd., Suite 200, Austin, TX 78759, (512) 338-0591.
Inquiry 1143.



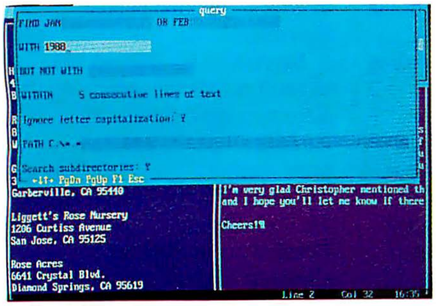
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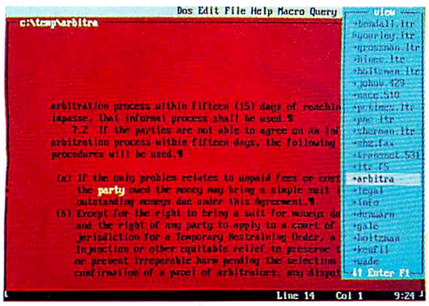
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The query panel is Vq's window into your disks.

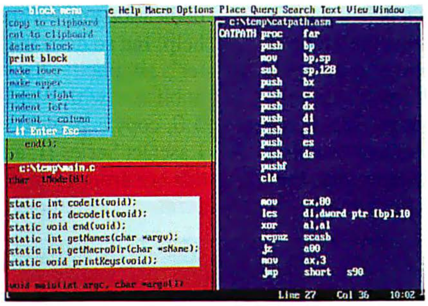
A MATCH FOR YOUR PATH—quickly search a file, a whole disk, or anything in between to find all the files with a match to your search pattern, then display each match *in full context!*



After a query, Vq lists the files containing the target pattern and displays the matching text, highlighted in context.

WHEN YOU FIND IT, USE IT with *Vq*'s full-featured editor or your own word processor, compiler, or custom macro.

A MATCH FOR YOUR CREATIVITY—expand your creativity into a screenful of windows for different files or different parts of a file. Zoom them, compare them, edit them in parallel, or copy-and-paste to a new file.



Vq's Block command menu is pulled down for processing the marked block of text.

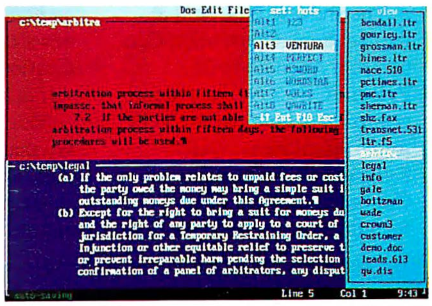
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A MATCH FOR YOUR MOUSE—full mouse support with pull-down command menus means you don't have to remember *anything*. All *Vq*'s power is delightfully accessible—just point and shoot!

A MATCH FOR SYSTEM FAULTS—while you're working, *auto-save* is working too, so you can automatically start each session where the last one ended—*even if it ended unexpectedly!*

A MATCH FOR YOUR APPLICATIONS—add *Vq*'s access and editing talents to the applications you know and love.



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Vq comes with Hot Links to popular applications, and creating more is a snap. Pass your desktop publisher the file you created, format it, print it, then return to *Vq* to find your sales summary and jump-start your spreadsheet program, or write brilliant code and Compile-and-display-next-error. *Vq* shrinks to just 7K bytes during linkage and gives your applications room to run!

A MATCH FOR YOUR CHORES—teach *Vq* whatever you do over and over. *Vq*'s macros learn any input sequence for flawless playback at your command, for infinite customization!

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Circle 478 on Reader Service Card (DEALERS: 479)

West Coast Government Computer Show

For the first time, the Federal Computer Conference (FCC) and the Defense and Government Computer Graphics Conference (DGC) will be held on the West Coast. The show will feature an exposition in hardware, software, peripherals, systems integration, graphics, maintenance, and other services.

The show will be held at the Anaheim Convention Center from April 25 to 28.

Price: FCC: $395 for federal government employees, $495 for nonemployees; DGC: $395 and $495, respectively.

Contact: National Council for Education on Information Strategies, 7315 Wisconsin Ave., 901 W, P.O. Box 41045, Bethesda, MD 20814, (800) 343-6944; in Maryland, (301) 961-6575.

Inquiry 920.

Sacra Blue: Keeping It Simple

An oft-quoted expression that your car is an extension of your personality can be applied to the users group newsletter: The appearance and content of your group's newsletter is a pretty good indication of what the group itself is accomplishing.

Most club presidents will say that although BBSes, meetings, and volunteer troubleshooters are important, the newsletter is the group's main drawing card. For members who don't have a modem and can't attend all the meetings, the newsletter is the primary, if not the only, source of group information.

The problem is, how do you publish an attractive, timely publication that serves all the group's needs without burning out your editor?

Sacra Blue, the publication of the Sacramento PC Users Group (SPCUG), averages 80 pages a month and is one of the better news magazines put out by users groups. According to editor Tony Barcellos, dedication and enthusiasm help, but so does the newsletter's simplicity. Sacra Blue is published with WordPerfect 5.0, copy is printed on an HP LaserJet Series II, and the ads are dropped in at the printer. The editors don't use desktop publishing programs such as PageMaker, but they still produce a highly readable, professional news magazine.

By avoiding the extra steps of desktop publishing, Barcellos said Sacra Blue has only a two-week lead time from author deadline to actual shipment of the month's edition. He noted, "It's not state of the art, like a PC Monitor [the Capital PC Users Group journal], but it's a lot more hassle to go that [desktop publishing] route."

Barcellos also said the key to good newsletter content is attracting the right mix of talented amateurs and professionals.

The SPCUG has about 2500 members.

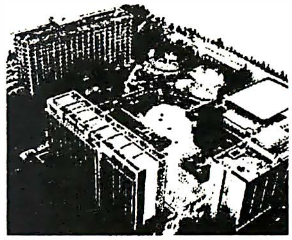
Price: Annual dues, $25.

Contact: SPCUG, Member-

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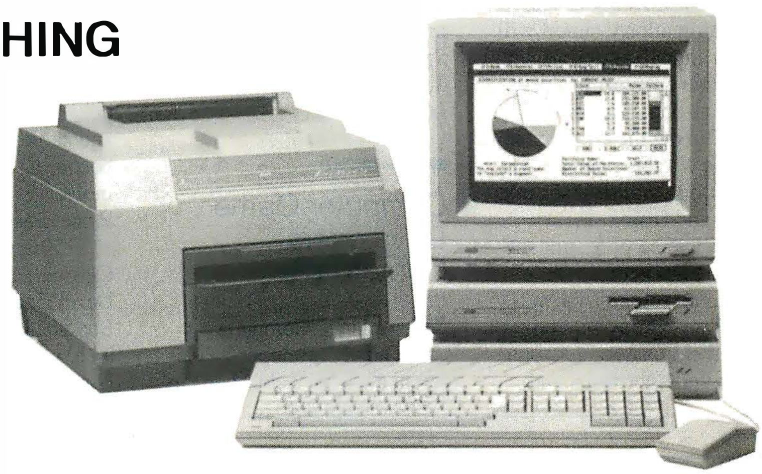
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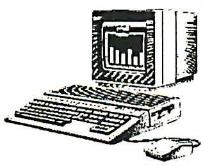
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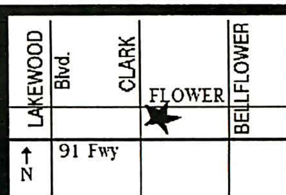
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ship Director, P.O. Box 685, Citrus Heights, CA 95611, (916) 386-9865.
Inquiry 921.

Robotics and Automation Conference

The IEEE Robotics and Automation Council will hold its annual conference at the Registry Resort in Scottsdale, Arizona, from May 14 to 19. During the conference, tutorials will be given on AI applications, multisensor integration and fusion, theory and application of redundant robots, autonomous mobile robots, and robot vision systems. Two all-day sessions will be held on May 19—one on parallel algorithms and architectures in robotics, and one on the integration of AI and robotic systems.

The tutorials and workshops will begin on Sunday, May 14.
Price: Conference: $185 for IEEE members; $230 for nonmembers; $100 for students. Workshops, $75 and up. Tutorials, $100 and up.
Contact: Robotics and Automation, P.O. Box 3216, Silver Spring, MD 20901, (407) 483-3037 or (301) 434-1990.
Inquiry 919.

Computer Game Developers' Conference

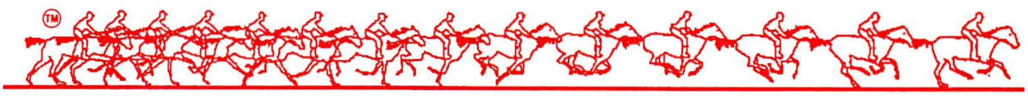
The Third Computer Game Developers' Conference will be held May 7 to 8 at the Sunnyvale Hilton in California. Conference sessions and roundtable discussions will be devoted exclusively to computer entertainment issues and will feature about 24 sessions in two tracks.

Some of the planned sessions include the process of building games, artificial personalities, publisher/developer relationships, the entertainment software marketplace, future game technologies, animation, the press and games, theft protection, becoming a publisher, and more.
Price: Postmarked by April 1, $150; by May 1, $175.
Contact: Computer Game Developers' Conference, P.O. Box 50282, Palo Alto, CA 94303, (415) 949-3379.
Inquiry 923.

Unix Executive Symposium

The international association of Unix systems users, /usr/group, will sponsor, with Patricia Seybold's Office Computing Group, a Unix executive forum. The symposium is aimed at executives of large end-user organizations such as Fortune 500 companies and the government.

The conference will take place from April 26 to 28 at the Santa Barbara Biltmore Resort Hotel.
Price: $995.
Contact: /usr/group, 2901 Tasman Dr., Suite 201, Santa Clara, CA 95054, (408) 986-8840.
Inquiry 922.


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Hard Disk Drive for the Mac Has Track Cache

The MacBottom HD84, an 84-megabyte hard disk drive for the Macintosh Plus, SE, and II, features a 1-to-1 interleave ratio with a 19-ms average access time and a track cache that anticipates the Mac's next request for data and stores it on the drive's controller card. According to Personal Computer Peripherals Corp. (PCPC), with the track caching enabled, the hard disk drive allows an access time of as low as 0 seconds.

The HD84 is 2 inches tall and weighs less than 5 pounds. The drive ships fully formatted and ready to run and includes print spoolers; FloppyCopy, a disk duplicator program; and Eureka!, PCPC's desk accessory for locating misplaced files. The drive also ships with HFS Backup 3.0, an archive and restore program that's MultiFinder and TOPS compatible.

Price: $2195.

Contact: Personal Computer Peripherals Corp., 4710 Eisenhower Blvd., Building A4, Tampa, FL 33634, (800) 622-2888; in Florida, (813) 884-3092.

Inquiry 904.



The HD84 can fit in your briefcase.

Accounting Software for Small Businesses

Phoenix Phive's Payroll 2 accounting program, a new version of the company's SBAssistant Payroll program, is for small companies with up to 200 employees.

Payroll can handle weekly, biweekly, and monthly payroll. The new version's enhancements include after-the-fact payroll, handling city taxes and 401(k) contributions, tax tables that you can modify, and the ability to accept time in hours and minutes as well as in hours and fractions of hours.

The program calculates Federal, State, FICA, and disability insurance, and city withholdings. It can also maintain personnel history and print paychecks and W-2 forms. Payroll can handle nine types of earnings: regular, overtime for first overtime or second shift, overtime for second overtime or third shift, holiday pay, sick pay, vacation pay, other pay (for bonuses or commissions), nontaxable pay, and tips. The program also has seven deduction fields, including medical, dental, clothing, union, 401(k), auto, and one other deduction field for one-time deductions.

Payroll works on the IBM PC with 256K bytes of RAM (384K bytes of RAM is recommended), MS-DOS 2.0 or higher, and a monochrome, EGA, VGA, or CGA graphics card.

Price: $95.

Contact: Phoenix Phive Software Corp., 7830 East Gelding Dr., Suite 400, Scottsdale, AZ 85260, (800) 331-1811; in Arizona, (602) 483-0991.

Inquiry 898.

File-Sharing Utility for Incompatible Mac Programs

Open It! is a desktop accessory for Macintosh users that lets you share files between incompatible programs, even if you don't have the application that you used to create the file. Open It! also lets you save files in a common file format, and while you're working in an application, you can access Open It! from the Chooser and merge the file into your working document.

With the program, you can create multiple ScrapBook files and scale graphics images or text on a scale from 1 percent to 1000 percent. The program supports MacPaint, PICT, Glue, and ScrapBook files.

A Print It! utility lets you print any file to disk, and you can access and place the file into any application or document. You can change font styles and sizes to match those of the document to which the information is pasted.

A thumbnail feature of the program also lets you view up to eight pages of a document at a time.

Open It! requires a Macintosh with 512K bytes of RAM.

Price: $89.95.

Contact: TENpointO, 3885 Bohannon Dr., Menlo Park, CA 94025, (415) 329-0800.

Inquiry 893.

Three-Dimensional Object Font Designer

InterFont is a font editor program for the Commodore Amiga that lets you create fonts that you can use in three-dimensional animation and modeling programs such as Sculpt 3D, VideoScape 3D, Turbo Silver, and Forms in Flight. You can also use the program to make structured clip art for Gold Disk's Professional Page desktop publishing program, according to InterFont's publisher, Syndesis.

Six premade serif and sans serif InterFonts are included with the package. With InterFont, you can also create your own custom shapes in up to 16 colors. The package also includes Syndesis's InterFont Designer, which you can use to trace over any Amiga bit-map font and create InterFonts, which you can enlarge, reduce, and make bold or italic without jagged edges.

InterFont creates lines of three-dimensional text automatically; you enter lines of text, and the package creates the three-dimensional object. The program can also adjust the size, shape, color, and texture of three-dimensional text objects.

The program can also create structured drawings in Aegis Draw format that you can import into Professional Page. When used with Professional Page, you can create custom logos and elaborate text at PostScript resolution; when used with Draw Plus, you can rotate and stretch text.

InterFont also includes InterChange, the company's object-conversion utility.

Price: $119.95.

Contact: Syndesis, 20 West St., Wilmington, MA 01887, (508) 657-5585.

Inquiry 896.

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- ☐ **Small Business Accounting 1.3** — An excellent accounting program designed for small businesses.

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- ☐ **Express Check** — A great program to manage your checking accounts!
- ☐ **Home Budget & Money Manager** — The title says it all! Easy to use.
- ☐ **Home Inventory** — Helps you keep track of everything you own. Great for insurance.
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- ☐ **Play 'n' Learn 2.03** — A collection of six programs for children 18 months to 4 years.
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- ☐ **World 2.93** — The ultimate globe! Learn about cities, countries and continents with this computer version of the globe. (CGA compatible graphics required)

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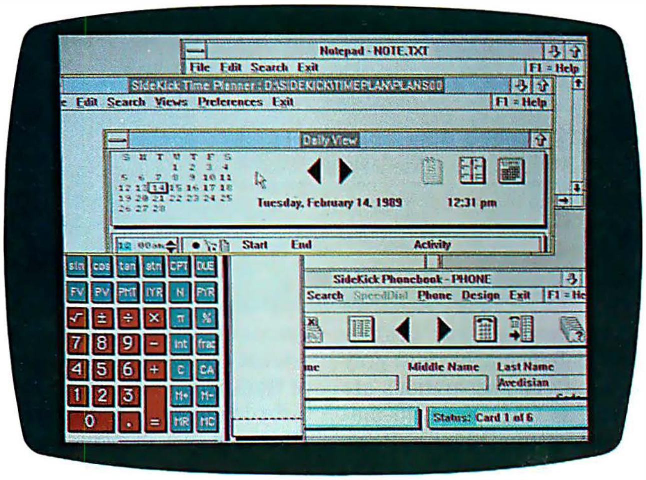
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SideKick for PM: More Than Just a Pretty Face

According to some industry pundits, one of the reasons for the apparently slow acceptance of OS/2 is the current lack of useful applications for Presentation Manager, the operating system's graphical user interface. But IBM has come to the rescue by including a free copy of Borland's new **SideKick for Presentation Manager** in every copy of OS/2 1.1. While it's only a hint of the applications that we'll be seeing for PM, it is a fully functional program that lets you do useful chores as soon as you've installed OS/2.

I found SideKick for PM to be both more and less than its better-known cousin, SideKick Plus.

Installation was a snap. Borland's installation utility copied all the files to my hard disk, edited my configuration file, and added a SideKick group to the group window in OS/2's Start Program application. SideKick for PM isn't a TSR program. This is OS/2, without the RAM-cram problem or the danger of applications bumping into one another.

SideKick for PM is a four-part product, with a calculator, a time planner, a phone book, and a notepad. If you're an experienced SideKick user, it's not hard to see that that's four fewer features than SideKick Plus. SideKick for PM lacks the file manager, clipboard, ASCII table, and outliner of the MS-DOS version. The file manager and clipboard aren't needed, simply because PM has them built in. The ASCII table isn't really necessary either, since PM's main market will be business applications. What about the outliner? A Borland spokesperson told me the company is working on enhanced versions of SideKick for PM.

But it didn't take me long to find that the four existing applications within SideKick for PM more than make up for what I'd thought was a lack of features. This is a completely new product, and it's a prime example of why I believe PM is destined to become an industry-standard interface. Borland's programmers have fully utilized PM's graphical capabilities. Unlike the character-based MS-DOS version, SideKick for PM is full of buttons, changing cursors, icons, and various fonts and font styles. Taken together, they uniquely integrate SideKick into a useful and easy-to-use program.

It would take much more space than I have to even begin to explore the new capabilities of SideKick for PM. But the phonebook and time planner bear special mention because they use the core database engine from Borland's Paradox. You can swap names, addresses, notes, and appointments to and from the Paradox files. And the time planner is a cutting-edge graphics application. I used a time odometer to select open appointment slots, and *child* windows (windows inside the main application window) let me see three different views of my schedule.

Although nonwindowed OS/2 applications have been available for over a year, SideKick for PM is the first application I've seen that truly takes advantage of PM. It's a tantalizing peek at what will be coming down the line. And since it's free with OS/2 1.1, you couldn't ask for a better deal. IBM and Borland have not announced how long their arrangement will last. SideKick for PM isn't currently available as a stand-alone product, but a Borland spokesperson says it will be available, eventually, for $250.

—Stan Miastkowski

THE FACTS

SideKick for Presentation Manager
Free with IBM OS/2 1.1; $250 when available separately

Requirements:
80286- or 80386-based IBM PC, PS/2, or compatible with OS/2 Standard Edition 1.1 or higher, PM, and 3 megabytes of RAM; a mouse is recommended, and a Hayes-compatible modem is needed for dialing.

Borland International, Inc.
1800 Green Hills Rd.
P.O. Box 660001
Scotts Valley, CA 95066
(408) 438-5300
Inquiry 1044.

Industrial-Strength Color Processing

The Macintosh II's color capabilities give it the potential to serve as a color image processing engine. **PhotoMac**, a color-retouching application written by Avalon Development Group and marketed by Data Translation, lets the Mac II achieve this potential. PhotoMac is designed to serve the color prepress industry: It lets you im-

continued

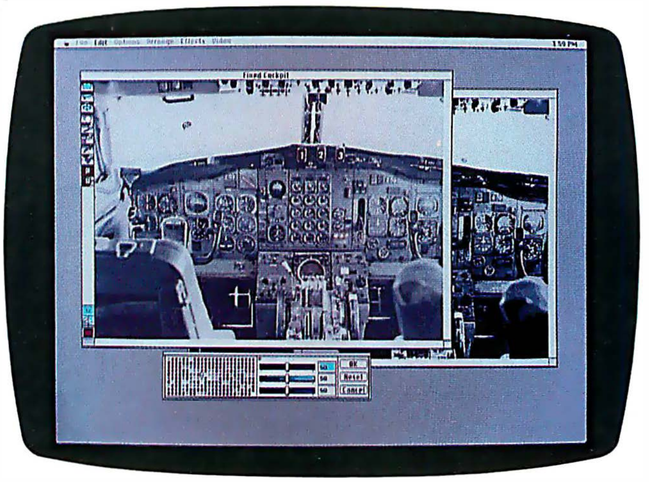
port 24-bit color scanned images and work with them using a set of retouching and design tools. You then save the modified images in several formats, or you can generate process color-separation files.

PhotoMac works on a Mac II or IIx with 2 megabytes of memory and a standard 8-bit color display. Since even small 24-bit color images can easily be larger than 2 megabytes in size, PhotoMac implements a virtual memory system. That is, only the portion of the image actually displayed consumes memory, while the rest of it is held in a disk file until needed. This lets you easily work on files larger than available memory.

How can you work on 24-bit color images reliably when your screen displays only 256 colors? PhotoMac features an adaptive display, where it uses the 240 colors that best represent the 24-bit data for the part of the image that's on-screen. The other 16 colors are reserved to display PhotoMac's tool palette.

PhotoMac imports a variety of color image formats: PICT, 8- and 24-bit PICT2, 24-bit Tag Image File Format, and TARGA or VISTA files. Once you are finished working with the image, you can save it as 8- or 24-bit PICT2 or 24-bit TIFF files. You can print directly to a Tektronix color printer or a Mirus film recorder.

To do color separations, you specify the screen lines,



screen angles, gray component enhancement, and gray balance. The separations are saved as CMYK (cyan-magenta-yellow-black) PostScript files, suitable for downloading to a PostScript typesetting system (e.g., the Linotype Linotronic 300). Since the QMS ColorScript 100 laser printer uses color PostScript and not CMYK PostScript, you'll have to import the image file into another application, like Quark XPress, to print it. Since the application is for high-end color prepress, the Apple LaserWriter II printer is not supported.

The tools let you magnify an image (up to 32 times) for precision work or reduce it (to one-eighth its size), and you can rescale it, flip it, or rotate it. You can modify its colors using either RGB or LHS (luminance-hue-saturation) color-correction systems, or you can retouch it with opaque or transparent colors using an airbrush or paintbrush tool. Of course, you can cut, copy, or paste images. A Copy transparent option lets you paste an image into a white region of an existing image. The image pasted is either scaled to fit the white region or cropped, as determined by a key selection during the paste operation.

I tried PhotoMac 1.0 on a Mac II equipped with 5 megabytes of RAM, a SuperMac 19-inch color monitor, and a Spectrum/24 video board. PhotoMac easily imported PICT2 files from PixelPaint and 24-bit TIFF color images made with Howtek's ScanMaster color scanner and MacScan-It 1.0 software. The tools were intuitive and easy to use. For long operations, a dialog box gives you a countdown in minutes and seconds with a Cancel button. Image manipulation seemed a *bit* slow, but because PhotoMac is working with 24-bit data and uses three temporary files to provide an Undo capability, the delays are reasonable.

The manual is one of the best I've seen: For any surprise that turned up while using PhotoMac, I found an explanation in the manual. It includes a tutorial section that explains how to use each tool, with examples. The reference section follows the traditional by-the-Mac-menu layout—that is, selection by selection through each of the menus.

If you want to do special effects for a publication, crank up the reds in a sunset, or take the green out of the faces of the board of directors, PhotoMac is worth a look.

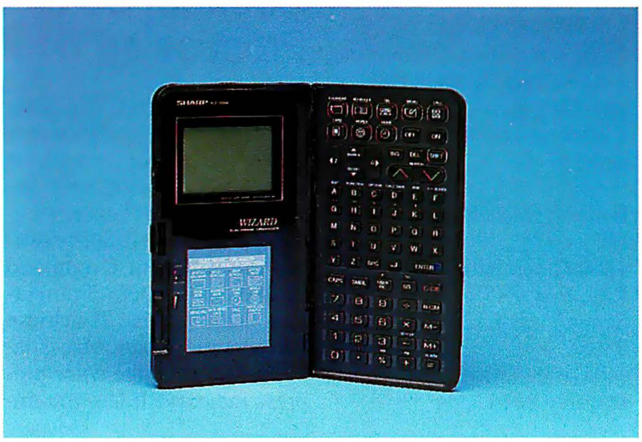
—Tom Thompson

THE FACTS

PhotoMac
$695

Requirements:
Mac II or IIx with 8-bit color board and monitor, 2 megabytes of RAM, and System 6.0.2/Finder 6.1 or higher.

Data Translation, Inc.
100 Locke Dr.
Marlborough, MA 01752
(617) 481-3700
Inquiry 1045.



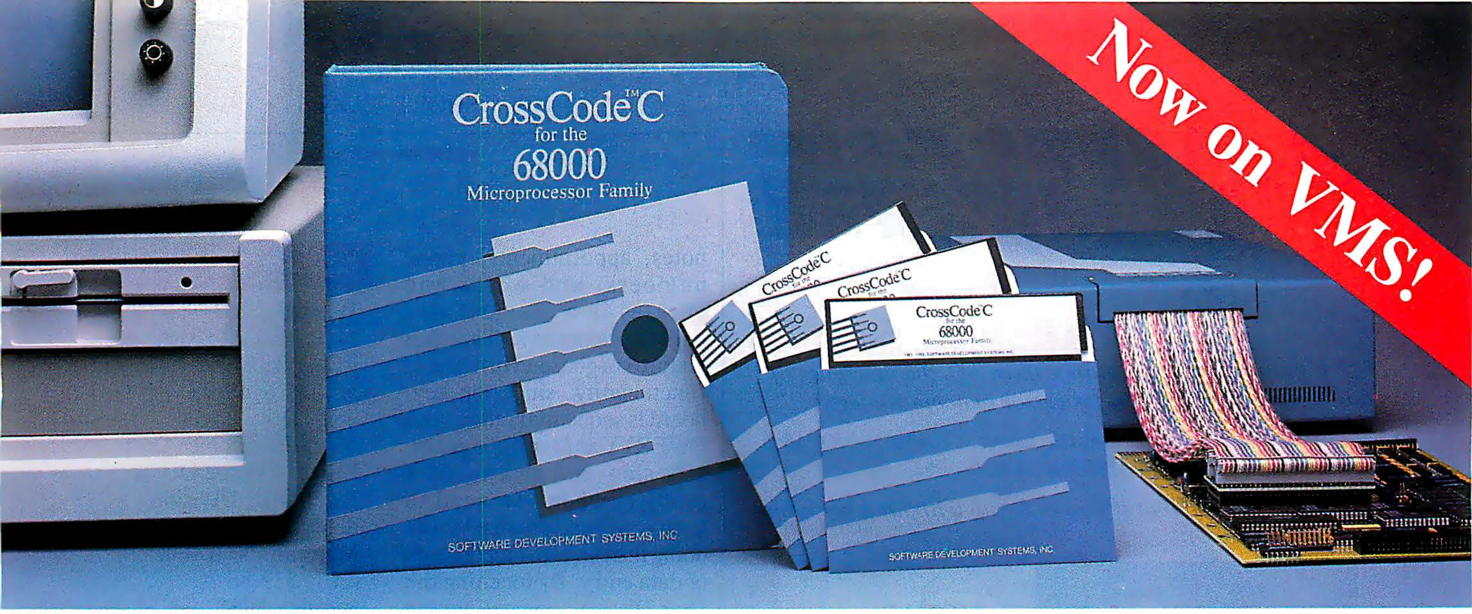
The Power of a Wizard

Designed as an electronic organizer, **Wizard** from Sharp Electronics is an 8-ounce pocket computer with 128K bytes of ROM-based software that performs the functions of a calendar, scheduler, memo pad, calculator, personal telephone book, and clock. Additionally, you can get optional "credit card" software packs that contain programs like a to-do list, a time and expense manager, a thesaurus/dictionary, and an eight-language translator.

Wizard comes with its own 32K bytes of RAM and can hold 64K bytes at one time (32K bytes of system memory and 32K bytes with an add-on card). If you buy all the cards, you have a total of 256K bytes; however, you can't use it all at one time.

Wizard lets you store your

continued



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4. Optimized Code: CrossCode C uses minimum required precision when evaluating expressions. It also "folds" constants at compilation time, converts multiplications to shifts when possible, and eliminates superfluous branches.

5. Custom Optimization: You can optimize compiler output for your application because *you* control the sizes of C types, including pointers, *floats*, and all integral types.

6. Register Optimization: Ten registers are reserved for your register variables, and there's an option to automatically declare all stack variables as *register*, so you can instantly optimize programs that were written without registers in mind.

7. C Library Source: An extensive C library containing over 47 C functions is provided in source form.

8. No Limitations: No matter how large your program is, **CrossCode C** will compile it. There are no limits on the number of symbols in your program, the size of your input file, or the size of a C function.

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10. Floating Point Support: If you're using the 68881, the compiler performs floating point operations through the coprocessor, and floating point register variables are stored in 68881 registers.

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12. ANSI Standards: CrossCode C tracks the ANSI C standard, so *your* code will always be standard, too.

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DEPARTMENT 23
4248 BELLE AIRE LANE
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notes, appointments, phone numbers, and words and phrases in a user-defined built-in dictionary. This last feature is a godsend in terms of functionality, since the keyboard is sequential rather than QWERTY and typing is generally slow and awkward—a problem when you need to keep your mind on what you're doing instead of the mechanics of data entry. By touching the User Dic key, you call up the dictionary function and can add or recall often-used sets of words.

In my case, a series of verbs (i.e., call, assign, go to, and meet) and the names of BYTE staff members let me schedule and enter most of the things I need to keep track of with about a half-dozen mostly repetitive keystrokes. I can then set the time for the task and tell the Wizard to ring an alarm to remind me of my next appointment.

The intensity-adjustable LCD shows either eight 16-character lines or four 10-character lines. The space is cramped, and the memo pad and scheduler wrap line endings without proper word breaks or hyphenation. What you wind up with, at first, is wasted time while you go back and put things in a readable order. But again, the user dictionary and a little practice give you a better feel for how much to enter before hitting the Return key.

The Wizard also comes with the ability to import and export data through a serial port. When connected to an IBM PC compatible via Traveling Software's Wizard PC-Link, you can, for example, transfer Borland's SideKick data from the PC into Wizard's scheduler. (SideKick Plus transfers did not work with our beta copy of the program, however, and required BYTE's editor in chief to write a short program to bring the data over.)

Another option, according to Sharp, is the ability to create hard-copy output by connecting the Wizard to Sharp's CE-

THE FACTS

Wizard, $299; software packs, $100 to $130;
PC-Link, $179;
printer, $169.99

Sharp Electronics Corp.
Personal Home Office
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Sharp Plaza
Mahwah, NJ 07430
(201) 529-8874
Inquiry 1046.

50P printer. Further, the company also offers an optional dubbing cable that it says can connect two Wizards and let them share information.

Wizard's calculator function is enhanced by having its own numeric keypad. It has a "paperless printer," or journal-tape function, that helps you keep track of your entries or edit previously input calculations. You can also perform calculations of data stored in the memo pad (e.g., summing price lists). The large-character display in calculator mode is also surprisingly handy.

I could do without the world clock function, but I can see where it might be useful for people who often need to know when would be a good time to put through a call to Seoul or London or Lagos. Another function I'd list as thoughtful on the part of the designers, but only potentially useful to me, is the Wizard's secret mode. Using it, you can password-protect data in your schedules, telephone directory, and memo pad.

In its basic configuration, the Wizard has a lot to recommend it. People like myself who normally have lots of discrete tasks to organize and manage—and who spend a lot of time away from their desks and TSR programs—can always use help in keeping track of events. However, the Wizard's price makes it a question mark for me. It retails for $299. Additionally, the extra software packs run from about $100 to $130 each, the Wizard

continued

How To Get In On Our Frequent Flyer Program



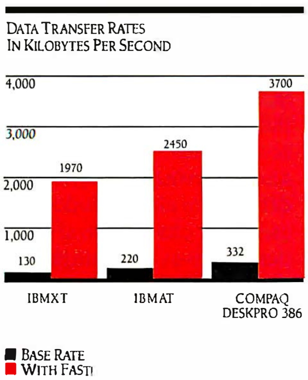
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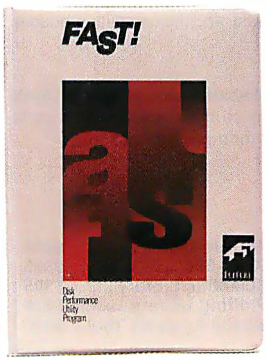
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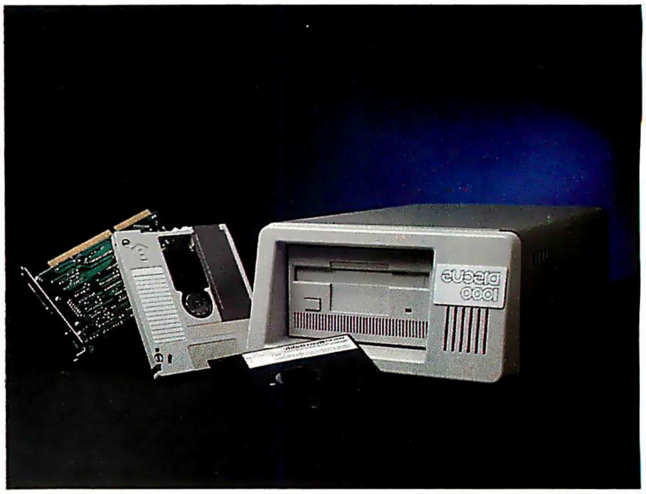
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Circle 319 on Reader Service Card (DEALERS: 320)

PC-Link costs $179, and the printer goes for $169.99. Once you start adding on, the price adds up.

I've used Wizard enough to know that I could eventually rely on it as easily and as naturally as a pocket notepad—and because of its automatic alarm capabilities, it's at least one cut above pencil-and-paper-based organizers. On the other hand, the price is a barrier right now. I'm not sure how much I'd be willing to pay just to have my notepad kick me awake for a meeting or to go harass some poor editor about a deadline. Of course, discounting is a fact of life. I'm making a note in my Day-Timer to check it out again in a few months.

—Glenn Hartwig



Discus Rewritable: The Latest in Storage Technology

One of the big surprises when Steve Jobs introduced the NeXT computer last October was its erasable, rewritable optical disk drive. Now, you don't even have to wait for a NeXT computer to get your hands on the latest in storage technology: A new optical disk drive from Advanced Graphic Applications (AGA) connects to an IBM PC AT and offers 650 megabytes of storage at a cost per byte comparable to hard disk drives.

Rewritable optical technology is the successor to WORM (write once, read many times) technology, which lets you permanently archive data on shiny, durable laser disks similar to audio CDs. The **Discus Rewritable** drive offers the benefits of a WORM drive—huge capacity, long-term stability of data, and portability—with the added flexibility of conventional magnetic media. And it's so fast that in tests with workaday software packages like databases and word processors, it performed nearly as well as (and in some cases better than) my trusty old hard disk drive.

The Discus Rewritable is available either in an internal, full-height configuration or as an external unit with its own power supply and fan. Both versions communicate via a SCSI port designed by AGA that is included with the product. Cables, documentation, and software utilities and drivers are also included. You can daisy chain up to six additional drives to a single controller through an external SCSI port on the back of the external model.

I tested an external model on several different com-

continued

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THE FACTS

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$4995 (internal),
$5495 (external)

Requirements:
IBM PC AT or compatible (no minimum RAM requirement) with DOS 3.0 or higher; SCSI controllers also available for IBM PC XT and Micro Channel.

Advanced Graphic Applications, Inc.
90 Fifth Ave.
New York, NY 10011
(212) 337-4200
Inquiry 1047.

puters. The setup and software installation were well explained in the manual and turned out to be very easy. I couldn't get the drive to work on one AT clone that turned out to have a strange direct-memory-access controller (the SCSI port uses a DMA channel), but this problem disappeared on a more fully IBM-compatible system.

The drive uses 5¼-inch magneto-optical disks supplied by 3M. One disk is included with the drive, and additional disks cost $250. Each disk holds 650 megabytes of data, or 325 megabytes per side, but you have to manually turn over the disk to access the other side.

As with conventional hard disks, you have to partition the disk, but this is simplified by a software routine supplied by AGA. (Disks are shipped formatted on side A, but you must perform a low-level format on side B that takes about 25 minutes.) Each side can be configured as a single giant partition. To set up partitions larger than 32 megabytes under DOS 3.0, however, you have to run a DOS patch provided by AGA. (This will not be necessary in the DOS 4.0 version, which was not yet available.)

On the downside, I found the external unit heavy and bulky, and its fan was very noisy. I was also annoyed by a few minor details, all of which I could live with: The Discus Rewritable always has to be turned on after the computer, disks have to be removed with the drive on, and they must be removed to lock the heads for transport. But overall, Discus Rewritable seemed to be a solid, reliable, and well-designed product.

Perhaps my greatest pleasure was the sensation of space I felt every time I saw the DOS DIR listing that said "322, 830,336 bytes free." It must have felt the same way to be a pioneer in the Old West and come upon an undiscovered territory.

—Andy Reinhardt

Talk to Me, DOS, Talk to Me

DOSTALK from SAK Technologies is a natural-language interface for MS-DOS-based computers. Instead of having to type in such cryptic commands as COPY C:\ARTICLES*.DOC C:\BACKUP, you simply enter the phrase "copy all the files in the Articles directory that have the extension Doc to the Backup directory" (capitalizing *only* the names of files and directories.) DOSTALK then translates that into the correct DOS commands and executes them.

Installing DOSTALK is fairly easy; an automatic installation program creates a subdirectory called DOSPEAK and copies several files from your DOS directory into it. The next time you reboot, DOSTALK will be available any time you press F2.

THE FACTS

DOSTALK
$129.95

Requirements:
IBM PC with 300K bytes of RAM and DOS 2.1 or higher.

SAK Technologies, Inc.
1600 North Oak St.
Suite 931W
Arlington, VA 22209
(703) 522-6425
Inquiry 1048.

DOSTALK does all the easy things: list filenames, copy files, and so on. I wondered, though, how it would do with fancier commands. Plain old DOS lets you invoke "switches" at the end of many commands to provide added features.

When I said "show Article-.doc one screen at a time," DOSTALK correctly invoked the MORE option of TYPE. "All right," I thought. "I'm impressed."

Unfortunately, DOSTALK then managed to mess up what I consider a fairly easy request: When I typed "show all the files that end in Doc," DOSTALK replied "Subdirectory Doc NOT FOUND." Not until I asked it to show the files that end with a Doc extension did I get what I wanted. This is supposed to be plain English?

There were other times when DOSTALK would get confused and go off on a long search for something I hadn't intended. For example, if you want to use a plain old DOS command, you have to type a $ first. I once typed DIR T*.* without the $, and DOSTALK asked "What should I do with the T*.* directory?" I replied "show them," and DOSTALK answered "Files T*.* NOT FOUND," even though there *were* files in that subdirectory that began with *T*. DOSTALK then proceeded to go looking for *all* the files on my hard disk that began with the letter *T*—a long list, and one that I didn't need to see. Unfortunately, DOSTALK doesn't let you interrupt once it has started on a long trek. (Sometimes, however, you can hit Control-C to abort an action.)

Yet another time, I asked DOSTALK to "print the names of the files," to which it replied "Name of list device [PRN]:." How many novices are going to know the correct response, LPT1? It then proceeded to print the *full text* of the files, rather than the directory list that I wanted. Urk! Where's the power switch on that printer?

DOSTALK does have some nice features, like the ability to undo the last command. And if you ask it to erase an entire subdirectory, it will ask you if you want to erase the files in it first. DOS just tells you that it's an "Invalid path, not a directory, or directory not empty."

One obvious omission from DOSTALK, though, is an on-line help facility. Any program (especially one that will be used by novices) that doesn't respond to a help cry with *some* kind of response deserves to go back to the shop.

Who needs DOSTALK? Certainly not someone who has been using a DOS machine for any length of time. Once you've learned the basic syntax, you can probably make DOS do what you want—faster, easier, and more flexibly than with DOSTALK. People with absolutely no DOS experience might find DOSTALK useful, but they'll probably need help from a DOS user to set it up. Even beginners will probably feel constrained by DOSTALK after a while.

—Ken Sheldon ■

S O F T W A R E   S E C U R I T Y

WHETHER REPORT.

Whether you're a software developer writing new applications for the IBM or Mac, or a PC user securing proprietary data files, software and data protection has never had a brighter silver lining. For a number of very good reasons.

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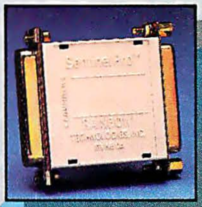
PC users wanting a low cost, user-friendly solution to the problem of securing sensitive data can call on the DataSentry. Using a proprietary Rainbow algorithm or DES, the DataSentry encrypts data files on individual PCs, protects modem transmissions and secures data on local area networks.

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Sentinel-C™

• Protects multiple packages with one device • 126 bytes of non-volatile memory programmed before shipment of the software • Rainbow supplies a unique adapter for programming the unit • Higher level language interfaces included • Runs under DOS, OS/2 and Xenix • External parallel port installation



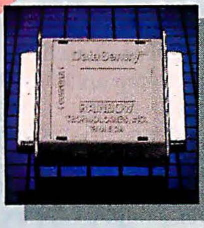
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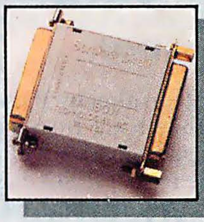
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Circle 313 on Reader Service Card (DEALERS: 314)

FIRST IMPRESSIONS ■ Steve Apiki

32.5 MHz and Climbing

Rated for 33 MHz and running at 32.5 MHz, SIA's 386/32 defines a new speed plateau

Just over a year ago, 20-MHz 80386 systems left us slack-jawed by the sheer power they delivered. A few months later, a clutch of 25-MHz machines provoked a similar reaction. Now, Systems Integration Associates (SIA) has begun shipping its 386/32, the first PC-compatible machine running on a 32.5-MHz clock—a unit that sets a new standard in microprocessor speed.

Chicago-based SIA managed to scoop the Compaqs and Advanced Logic Research machines by putting together a system board designed for 32 MHz with an Intel chip rated for 25 MHz and some additional hardware to keep things running smoothly. At the heart of the system is a high-speed cached memory design and cooling equipment dedicated to keeping chips close to their rated temperature while running above their rated clock speed.

Integration by Parts

While not a from-the-ground-up manufacturer like some of the bigger names in the industry, SIA has assembled an impressive machine by combining a good collection of subassemblies and adding a few touches of its own to cover up the seams. The basic system, which lists for $13,100, includes the system board stuffed with 4 megabytes of RAM, a case, a 200-watt power supply, a hard disk drive controller, a serial/parallel card, and a keyboard. The fully loaded evaluation unit weighed 70 pounds. It was mounted in an optional tower case that stands a good 6 inches taller than a PS/2 Model 80. With hard disk drive, tape drive, and coprocessor, the unit lists for $19,830.

Chief among these integrated subsystems is a motherboard built to handle 32.5-MHz operation. The 30 percent increase in frequency from the last generation means that physical problems, like stray capacitance and transmission line effects, become more acute, requiring careful board layout. Also critical to a good design is a memory subsystem that won't bottleneck the processor.

To keep up with 32.5-MHz operation, a conventional design would require 30-nanosecond static RAM. SIA gets around the prohibitively expensive solution of implementing the entire main memory in 30-ns SRAM by using a 64K-byte, direct-mapped, 20-ns SRAM cache. SIA claims zero-wait-state operation and an 81 percent hit rate for the write-through cache, operated by a discrete logic controller. In a direct-mapped design, each memory access involves comparing a *tag* (which specifies blocks within the cache) with part of the requested address. The system uses faster 15-ns SRAM to store the frequently used cache tags, further enhancing performance. Up to 16 megabytes of main memory can be cached; accessing any memory installed beyond this limit will slow the system considerably.

The main memory is made up of relatively fast 70-ns DRAMs. Four banks for dual in-line package memory are available on the motherboard, along with 4 single in-line memory module slots. DIP sockets are compatible with both 256K-byte and the larger 1-megabyte DRAM chips. SIA claims that both SIMM and DIP sockets will be compatible with the not-yet-released 4-megabyte versions of each package. With 1-megabyte parts, you can get up to 8 megabytes on the motherboard; when 4-megabyte components are released, the board will take not 32, but 16 megabytes—a system board limit imposed by the BIOS. An additional 24 megabytes can be added via the single 32-bit I/O slot, but, in any case, the upper addressable limit is 32 megabytes.

The processor itself is a 25-MHz Intel 80386 that has been tested for operation at 33 MHz by SIA. Both the 25-MHz Intel 80387 and Weitek 3167 coprocessors are supported.

The greatest difficulty in running a device beyond its listed rating is chip heating, as heat generation increases with clock speed. To keep things cool, SIA has mounted a cross-flow blower just above the processor and coprocessor socket, which, the company claims, keeps the chip case very close to ambient temperature. The CPU is also mounted slightly elevated (3/32 inch) from the socket, allowing air to flow underneath as well. I checked temperature differences with a digital thermometer. The chip case got as high as 11°F above ambient (i.e., 86 degrees) but never showed any adverse reaction to the heat.

SIA plans to offer early buyers of the 386/32 an upgrade to the 33-MHz CPU once Intel makes it available. The swap will cost those users a maximum of $500 with the return of the 25-MHz chip. SIA had not determined the exact upgrade charge at this writing.

Except for the high-speed modifications, the board looks like any number of 25-MHz 80386 motherboards currently available (see photo 1). It also interfaces just as easily, because the one 8-bit and six 16-bit I/O slots can run at a compatible bus speed of 8 MHz. The BIOS, designed by American Megatrends International (AMI), includes ROM-based setup and diagnostics and allows video BIOS relocation. I found that video BIOS relocation meant a threefold performance increase in some graphics functions, but it

continued



PHOTOGRAPH: PAUL AVIS © 1989

Table 1: *Benchmark results of a comparison between the SIA 386/32 and the ALR FlexCache 25386. For indexes only, higher numbers reflect better performance.*

CPU	SIA	ALR
Matrix	2.10	2.60
String Move		
Byte-wide	15.54	16.20
Word-wide:		
Odd-bnd.	17.78	21.97
Even-bnd.	7.78	8.13
Doubleword-wide:		
Odd-bnd.	13.14	15.93
Even-bnd.	3.87	4.03
Sieve	11.02	14.02
Sort	8.26	10.50
☐ **Index:**	**5.99**	**5.07**

FLOATING-POINT	SIA	ALR
Math	3.79	4.90
Error[1]	0.00E+00	0.00E+00
Sine(*x*)	1.23	1.54
Error	2.00E−09	2.00E−09
e^x	1.20	1.81
Error	1.00E−09	1.00E−09
☐ **Index:**	**14.20**	**10.55**

DISK I/O	SIA	ALR
Hard Seek[2]		
Outer track	3.33	1.64
Inner track	3.31	3.33
Half platter	6.65	6.67
Full platter	9.10	8.35
Average	5.60	5.00
DOS Seek		
1-sector	10.23	6.93
32-sector	18.77	15.35
File I/O[3]		
Seek	0.04	0.06
Read	0.85	0.49
Write	0.76	0.78
1-megabyte		
Write	2.89	2.91
Read	4.28	2.92
☐ **Index:**	**2.36**	**2.74**

VIDEO	SIA	ALR
Text		
Text average	3.21	4.60
Graphics		
Graphics average	1.96	1.94
☐ **Index:**	**3.06**	**2.57**

Application Indexes	SIA	ALR
Word processing	4.41	4.41
Spreadsheet	4.07	4.13
Database	2.02	2.83
Scientific/ Engineering	6.24	5.80
Compiler	3.94	4.08
☐ **Index:**	**20.67**	**21.24**

All times are in seconds. Figures were generated using the 8088/8086 and 80386 versions (1.1) of Small-C.

[1] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.

[2] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).

[3] Read and write times for File I/O are in seconds per 64K bytes.

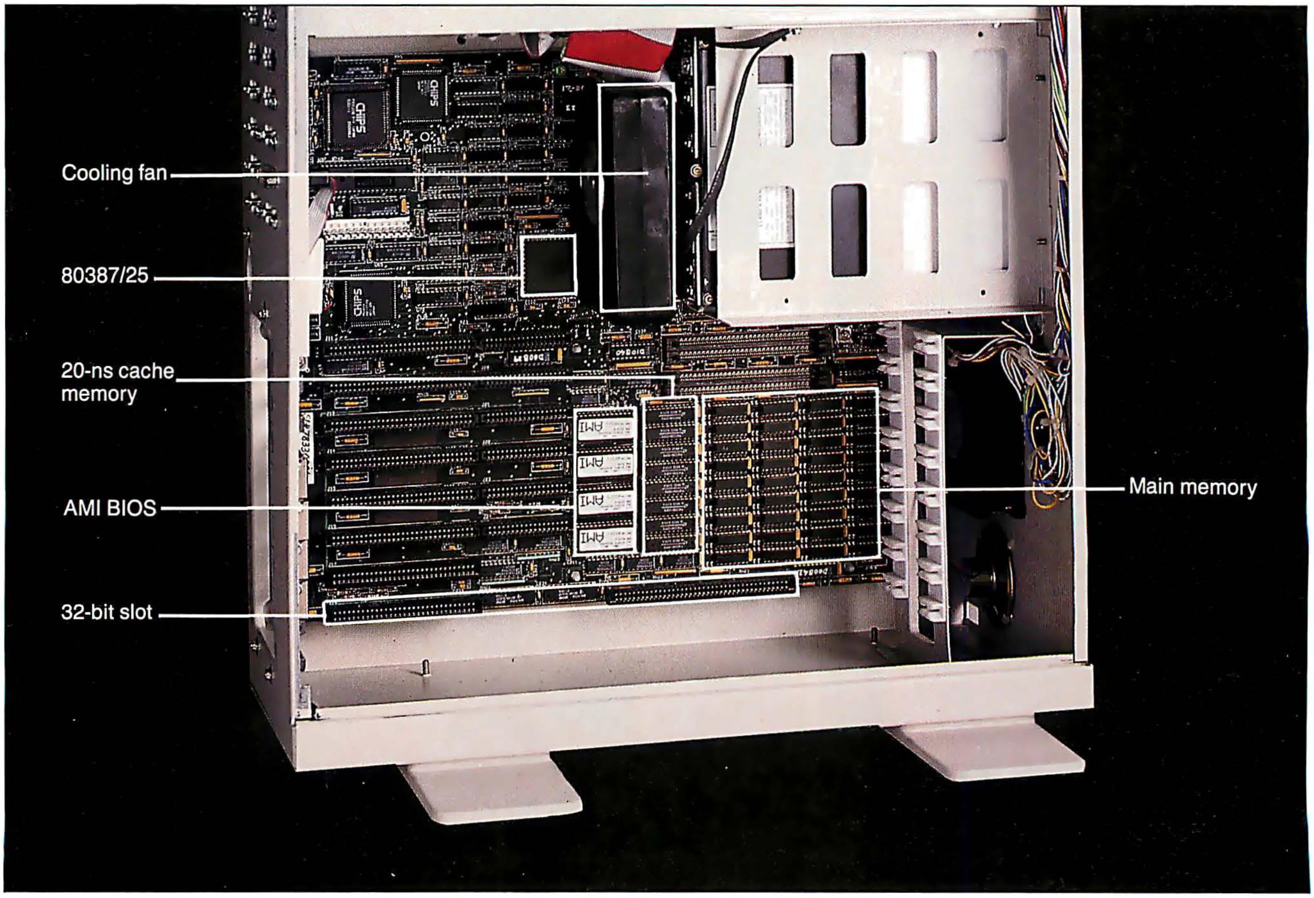


Photo 1: *The SIA 386/32's interior. The most striking departure from conventional systems is the presence of a dedicated CPU fan (CPU is mounted behind fan).*

will cost you 256K bytes in RAM above 640K bytes. The BIOS also allows you to toggle between 32.5- and 8-MHz CPU speed and to enable or disable caching with a hot-key sequence.

The disk subsystem, of course, often causes a bottleneck when combined with a high-performance CPU. SIA went a long way toward solving that problem by providing an ESDI controller as part of the standard system. The controller, an Adaptec ACB-2322, supports two hard disk drives and two floppy disk drives. With a data transfer rate of 900K bytes per second, the controller is well matched with the rest of the system. The unit I looked at included a very quick (16.5-millisecond rated access) 150-megabyte Control Data hard disk drive (which is not part of the standard configuration), adding to the system's impressive specs.

The unit also included a 150-megabyte tape backup system, two floppy disk drives, an 8-bit VGA controller, and an analog monitor. The monitor display is crisp, and the keyboard has an excellent feel. Unfortunately, the system unit interferes with the monitor when they are close together, and the standard monitor cable is quite short. The unit is FCC Class A-approved for business but not home use.

Proof in Performance

I test-drove the SIA 386/32 with BYTE's standard benchmark suite. Not surprisingly, the system set new performance records in most of the tests (see table 1). That word *most* is of critical importance; what's interesting is that this 32-MHz system could not quite out-distance the entire the 25-MHz pack. For the purpose of comparison, table 1 lists the SIA 386/32's benchmark numbers next to those for ALR's 25-MHz FlexCache.

The low-level CPU and FPU benchmarks reveal the kind of performance you'd expect—the SIA is consistently faster than the FlexCache. While the times vary slightly from test to test, the SIA's overall CPU index shows a performance increase over the FlexCache of about 18 percent. FPU performance increase is about 35 percent. These numbers are impressive indeed, considering ALR's 386/25 was the fastest unit we'd tested until now, but the relative CPU performance doesn't quite measure up to the 30 percent difference in CPU clock speed.

Disk speed was good, and the Adaptec/Control Data ESDI combination certainly did not result in any noticeable waits. Unfortunately, the disk subsystem

Processor speed is not an end-all measure of performance.

was outperformed by ALR's similar ESDI unit. While write operations and seek times are roughly equivalent, the SIA's disk-read scores are poor.

I tested the 386/32 using the video shadow-RAM feature, which made graphics operations fly. ALR's 16-bit VGA adapter had outstanding graphics speed, which proved unreachable for the SIA 8-bit card, but the SIA came out with a higher overall score.

These minor shortcomings in disk and graphics performance significantly hampered the 386/32's application performance, and the overall application index is actually slightly lower than the 25-MHz FlexCache's. Disk-intensive database operations were disappointingly slow.

High speed can mean software incompatibility if floppy disk drives run too fast, but that wasn't the case with the 386/32. The system had no problems with copy-protected Lotus 1-2-3, an application that usually weeds out systems with incompatible floppy disk speeds.

Final Thoughts

The SIA 386/32 promises excellent processing speed, and its high clock rate and cached memory design deliver. With the aid of the interior blower, the 25-MHz-rated chips run without difficulty. When armed with a high-speed coprocessor, there probably isn't a faster PC-compatible number cruncher available today.

Processor speed is not, however, an end-all measure of performance, and number crunching is not a computer's only function. Some of the peripheral components could not keep up with the CPU, and application performance suffered. These units can be replaced and indeed are not even part of the basic system. Replacements are unlikely to save money—this top-shelf system requires top-shelf parts; it's hard to imagine a 386/32 that fully exploits its system board power for under $17,000. ■

Steve Apiki is a testing editor for the BYTE Lab. He can be reached on BIX as "apiki."

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LANGUAGE SOJOURN

Jerry explores the highways and byways of programming choices

It won't be finished here, but I'm beginning this column on the island of Molokai. To be exact, I'm at the Kaluakoi Resort, which is on the northwest corner of the island. Like most people, the only thing I knew about Molokai—which is written locally Moloka'i and pronounced Molokay-aye—is that there is a leper colony here, but you're supposed to say Hansen's disease.

Actually, while there is a hospital community on the Kaluapapa Peninsula and some of the former residents live there, the isolation of Hansen's disease patients—begun here by decree of King Kamehameha V in 1865—hasn't been the law for years, since Hansen's disease is now completely controllable.

I'm here for the conference on Grand Challenges to Computational Science, where I'll be the dinner speaker. I also expect to learn a lot about the future of supercomputing. More on that later.

Languages Reconsidered

Before I left, I did a lot of work on Mrs. Pournelle's Reading Program. This was originally begun by Bruce Tonkin in Microsoft BASICA. Tonkin writes many of his programs for TNT Software in BASICA and sells some amazing products, complete with source code, at quite reasonable prices.

Then about a year ago, I began converting the Reading Program into Compiled BASIC. I tried Borland's Turbo Basic, then I tried Microsoft QuickBASIC 3.0, and I went from there to QuickBASIC 4.0.

I don't get to do a lot of programming. This project was certainly the biggest one I worked on last year. Since I use real projects to learn, get used to, and evaluate other programs and products, I was more than once tempted to abandon BASIC and work with another—and presumably more modern—language.

There were a number of contenders. I'm still fond of Modula-2. Logitech's Modula-2 system has an excellent debugger and a good working environment for PCompatibles. Workman & Associates has FTL Modula-2 for both PCompatibles and the Atari ST, so I'd have at least that much portability for the code. There are many good libraries of program modules that go a long way toward overcoming Modula-2's rather primitive I/O and string-handling capabilities.

Another possibility would be Borland's Turbo Pascal 5.0; certainly that would be hard to beat for sheer popularity, and the new Borland Turbo Debugger is neat and fairly easy to learn. One—perhaps the main—reason Modula-2 hasn't caught on as fast as I thought it would is that Turbo Pascal 5.0 incorporates many of Modula-2's major features while remaining easy to learn. It also compiles like lightning.

Finally, Turbo Pascal has become popular enough that literally dozens of programmers have developed packages of thoroughly tested and debugged subroutines you can incorporate into your programs; it's not necessary to invent the wheel each time. For example, Robert Jourdain's *Turbo Pascal Express* (Brady Computer Books, 1988) comes with a whole slew of useful assembly language routines. You can also get the Peabody on-line help utility to make learning and using Turbo Pascal even easier.

Something Completely Different...

Of course, I already more or less know Pascal, Modula-2, and QuickBASIC. For a while there, I toyed with the idea of using this project as an opportunity to learn something entirely new.

One choice would be Ada. I keep hearing contradictory tales about that language. One group says it was designed by a committee and shows it: there are too many features, so that the resulting language is too big and too slow and just not useful for practical programming.

A second group says that's all nonsense: Ada is a splendid language, no more complex than many others, especially if you don't use some of the special features. They say the RR Software Ada Compiler for PCompatibles is plenty good enough for production work, and it produces code that's competitive in speed and size with any other language's output. After all, RR's Compiler is written in Ada and compiles itself nicely.

It would be instructive to find out which group is right.

There are certainly differences in philosophy between Ada and Modula-2. For one thing, Ada incorporates exception handling, something that's anathema to Modula-2's designer Niklaus Wirth ("anyone who needs exception handling just doesn't know how to program"). The designers of Ada, on the other hand, wanted a programming language that would write code to handle real-time events, and not all of those can be predicted; they thought they had to have capabilities to handle problems no one had foreseen, since Ada was to be used for all Department of Defense programming.

On the other hand, Ada has modularity and variable hiding like Modula-2, and in fact there's more similarities than differences between the languages. They're both nearly self-commenting, too. Certainly they resemble each other more than either one resembles BASIC or FORTRAN. I haven't had enough experience with Ada to get any real feel for it, but from what Ada code I've read, it wouldn't be that hard to learn Ada and get used to working with it.

Another possibility would be Turbo Prolog. Mrs. Pournelle's Reading Program presents lessons and elicits re-

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sponses. Then it evaluates the response and does something appropriate, like show a graphics reward, play a tune, go back to review the lesson, or present new material. Since this is all done according to logical rules, it seems to me that Prolog would be a very appropriate language to work in. We expect to develop a whole family of educational programs once the Reading Program is finished, and using Prolog could make that easier.

Finally, there's Trilogy, a new language that combines many of the procedural features of Pascal with the logical operations of Prolog. I haven't had a chance to learn Trilogy thoroughly, but from the little experience I've had with it, I suspect it has great potential for both experimental and production work. It's very fast, and it's actually easier to learn than Prolog; I've been quite favorably impressed, and indeed, if I were going to change languages, Trilogy would be a very strong contender.

It's Still QuickBASIC

After all the thought about new languages, I finally stayed with QuickBASIC. There were several reasons, but chief among them are that QuickBASIC now has all the data structures and algorithms of any other procedural language—and I already know the BASIC syntax. With all the others, including Turbo Pascal 5.0, I'd have to do some relearning and lose old habits.

I'd also have to translate about 20,000 lines of code. That's not necessarily bad. I have to recode about half the program anyway, since it was originally written by several people who didn't use the kind of top-down programming structure I like. Still, it's easier to recode from BASICA to QuickBASIC than it is first to learn Prolog or Trilogy, then to figure out how to organize the program along logical rather than procedural lines.

Actually, even that's not necessarily true. Given a solid block of time to sit down and work on the program, I still think I'd be better off starting over, probably with Trilogy; but the trouble is, I don't *have* a solid block of time. I *never* get a chance to just sit down and program for several days. I've been working on Mrs. Pournelle's Reading Program in fits and starts, often while on the road; and while the Zenith SupersPort 286 is more than adequate for programming while traveling, there is a limit to the amount of paperwork and documentation I can haul around. Hotel rooms are not an ideal place for learning new languages.

Thus, I stayed with QuickBASIC, despite its bugs; and bugs it does have.

One of the most annoying bugs showed up only when I ran the compiled Reading Program on a fast 80386 machine that had an 80387 chip in it. The interpreted version—one of QuickBASIC's most attractive features is its ability to run in interpreted mode so that you can do a lot of interactive debugging—ran fine on my Big Cheetah 80386/80387. The code compiled fine. It ran fine on the Kaypro 386i with an 80287 math chip; but when I ran the compiled code on Big Cheetah, I got overflow errors in converting stored graphics images. It wasn't a problem with Big Cheetah, because we got those same errors on a Compaq Deskpro 386 with an 80387. There was something wrong with Microsoft's code generator.

Fortunately, that bug and a number of others were fixed when Microsoft brought out QuickBASIC 4.5. For reasons I don't understand, Microsoft did *not* inform all the registered QuickBASIC 4.0 owners of the 4.5 update; that is, they not only didn't tell me (and I do send in registration cards, even for review software), but they didn't tell a number of my readers who have written to me about it. So, if you have QuickBASIC 4.0, be sure to get it upgraded.

Version 4.5 also has some bugs—I can still manage to get run-time errors in compiled versions of code that ran fine in the interpreted mode—but there are far fewer of them. Moreover, the documents are better, and the programming environment has been simplified. All in all, version 4.5 is a distinct improvement.

In fact, it's enough of an improvement that, while I still believe that Prolog or Trilogy would be better for the type of program we're producing, I find QuickBASIC good enough; and in line with my view that better is the enemy of good enough, we're doing the full production model of Mrs. Pournelle's Reading Program in QuickBASIC.

A Cautionary Tale

QuickBASIC 4.5 has modularity and separate compilation; that is, you can write parts of your program as distinctly separate modules, completely debug them, and generally check them out; compile them; and put the compiled object code into a program library. You can then incorporate those procedures and

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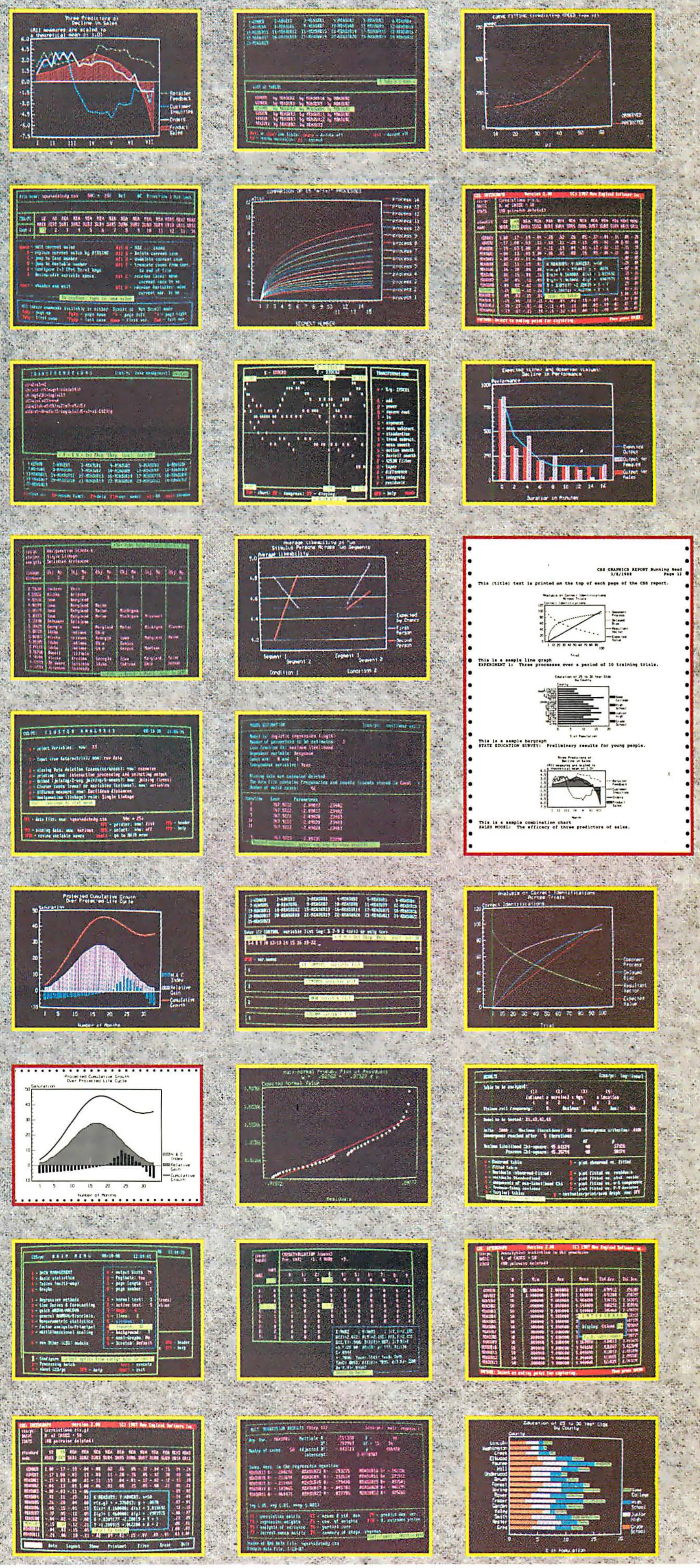
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This is one of QuickBASIC 4.5's more attractive features. The general notion is that when you write a program, you ought to write it such that much of the code can be used again in other programs. This saves a lot of work and lets you get new programs going faster.

There's one problem. The Microsoft program to build libraries isn't especially easy to use. It's not complicated, but building a library of many different routines can be quite tedious; I've often wished for a program that would make it simpler to make new libraries or change the contents of old ones.

Then I got QuickBASIC Tools from Project X Software. This looked to be the answer to my prayers. Not only did the product include a library-construction program, it also had a whole bunch of precompiled and presumably debugged procedures and functions that I could incorporate into my QuickBASIC program. There were over a hundred of these subprograms, and nearly every one of them appeared useful.

There were routines to check on the existence of a file. Routines to get and change the date of a file. Routines to open dialog boxes and get responses. Routines to get characters from the keyboard and check to see if those characters were in a previously specified set (so that you can, for instance, demand that the user enter either *Y*, *y*, *N*, *n*, *Q*, or *q*, and the routine will ignore any other input). Routines to open, close, rename, and copy files. Routines to make different beeps and chirps. Routines to manipulate dates and return day of year or Julian day, or reformat the date from U.S. to European style.

All of these are available as callable subprograms or functions. No need to write your own: simply use the library manager to choose the routines you want, and let that manager program not only build you a library containing only what you want, but also build you an include file of the proper DECLARATIONS. Some of the functions duplicated stuff I'd already written, but they looked to be more compact. Others were things I'd wanted to include in the program but either hadn't gotten around to or had reluctantly decided I wouldn't have time to

continued

write myself. Consequently, QuickBASIC Tools looked to be exactly what I'd been needing for a long time.

(Unfortunately, after this column was written, Project X Software went out of business. QuickBASIC Tools is no longer available.)

First Problems

Of course, I had a rather old (six months or so) copy of QuickBASIC Tools, but so what? It was supposed to be thoroughly tested. So, not long before Christmas, I sat down to build myself a library with a dozen of the most useful tools. While I was at it, I'd also use the library manager to link in a couple of general-purpose functions I'd written myself.

The library manager trundled away for a while. I could understand why it took a while. According to Project X, the library manager examines each library function to see if that one calls some other function; if it does, it includes that new function and looks to see if *it* calls something not already on the library list. I could see how that feature alone could save me a lot of time.

Eventually, the library manager finished. Rather eagerly—this looked like it was going to make it much easier to finish up Mrs. Pournelle's Reading Program—I invoked QuickBASIC in a way that included the resulting Quick library. (When you build libraries for QuickBASIC 4.5, two are constructed, a regular LIB that's linked into your compiled code, and a Quick library that you use when running QuickBASIC 4.5 in the interpreted mode.) Then, without using any of the new functions, I started up my program. I didn't anticipate any problems. After all, it ran fine the last time I'd used it.

It wouldn't run. There were "unresolved external calls," meaning that the program was looking for functions that were not in its library.

I rather angrily called Project X and got the president (and chief programmer). I explained who I was. He explained first that I had a "very old" copy of their product; and second, that they had just learned that when Microsoft changed from version 4.0 to version 4.5, they made a number of internal undocumented changes in the program. In particular, they changed the names of some of the internal subroutines. Some of these were called by the Project X tools and by the library manager.

However, he said, they had just solved that problem, and they would send me, via Federal Express, the revised product that had been out for several weeks and the newest revisions that would enable it to work with QuickBASIC 4.5. Since there were no changes in the tools themselves, only in some internal stuff, everything should work just fine.

Two Good Days

The new tools came on Friday. Early Sunday morning, we were scheduled to catch the plane to Molokai. Mrs. Pournelle's Reading Program was very nearly done. The only things that remained were polishing it and adding some administrative stuff like keeping records of which students had completed what lessons and a way to set the pass/fail percentage for each student. I was thus eager to get to work, so I opened the revised version of QuickBASIC Tools the instant it arrived.

There were extensive revisions from what I had: lots of new tools and thoroughly new documentation (which, alas,

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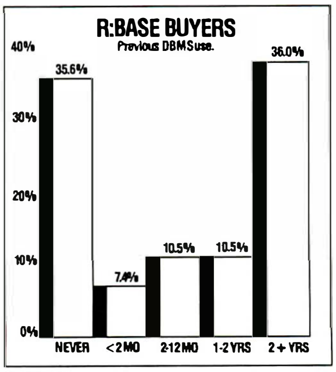
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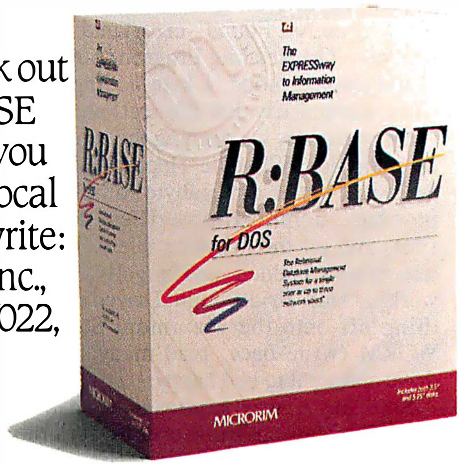
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was misprinted, not so badly as to be unusable, but badly enough to be frustrating). The library manager was rather different, too, but it was quite easy to use. I got to work building up a new LIB and Quick library.

This time, everything seemed fine. I added a whole bunch of new stuff, including the FILEXISTS function (it rather cleverly looks at the file's date rather than attempting to open it; that way, it avoids having to trap QuickBASIC's "File Not Found" error) and input routines. The Reading Program ran fine in interpreted mode. I kept adding features, particularly disk file stuff and also some provisions for running the program on multiple 360K-byte floppy disks (it takes just under a megabyte to hold the program, administrative files, lesson files, and all the graphics files). I kept testing what I added, and by golly, it was working fine. Friday night I saved everything off onto the Maximum Storage WORM (write once, read many times) drive and went to bed happy.

Saturday I was supposed to pack. Also, Jim Ransom came over to work on our SSX (Space Ship Experimental) briefing. All that was secondary for me, though; I was about to *finish* the Reading Program and get that sucker *out the door*. A great feeling. I worked a good part of the day, paused for dinner, and had at it again. By 10:00 at night I had it done. Two good days of work.

Disaster

There were two more things to do. One, I'd been running under interpreted mode, and I'd have to compile the program. Second, while I'd been working on the computer program to present the stuff, Mrs. Pournelle had been revising the lessons themselves. In doing it, she'd revised their order and added a couple in the middle of the sequence. The upshot was that of the 70 lessons, about 35 needed to be renumbered. Each lesson is accompanied by two graphics files, so I was really talking about copying and renaming some 105 files. While I could do this by hand, I sure didn't want to, especially since I could describe the changes I needed with a couple of FOR...NEXT loops in BASIC.

The only problem is that BASIC does not have a FILE COPY utility. The only way to copy a file in BASIC is to open it, read it, open an output file under the new filename, and write to that. This isn't all that slow on a Priam 330-megabyte hard disk drive, but it's not all that speedy, either; more important, writing the code at 10:00 p.m. after a long day wasn't very attractive.

However: the Project X tools include a FILE COPY utility.

Wonderful, thought I. First things first: I copied the original lessons and graphics files to the K partition of my Priam hard disk. I already had copies on the WORM drive, and of course Mrs. Pournelle had copies downstairs, both on floppy disks and on the Priam hard disk in her Kaypro 386i, so my latest copy was really gilding the lily; but anyway, I did it. Then I wrote a BASIC program that looked something like the following:

```
FOR i% = 68 TO 34 STEP -1
  j% = i% - 1
  PRINT "Copying Lesson";i%
  COPY
(F:\QB4\READ\LESSON.i%,
G:\READ\LESSON.j%)
  COPY
(F:\QB4\READ\BANNER.i%,
G:\READ\BANNER.j%)
NEXT
```

and so forth. The notion was that I'd build up the correct files on drive G, then copy the whole mess back into drive F, after which I'd be done. The whole thing shouldn't take more than 10 minutes, and the worst that would happen would be that I'd have to go get the stuff off K and start over.

I checked the code several times to be sure it would do what I wanted and told the program to run.

Nothing happened. Nothing at all. After a while, it was obvious that nothing was going to happen.

I hit Control-C. Then Control-Break. Then Ctrl-Alt-Del. None of those produced any result whatever. Finally, I hit the hardware reset on Big Cheetah.

It wouldn't boot. In a mild panic, I turned off the machine, waited a full minute, and turned it back on. It still wouldn't boot.

It was now 11:00 p.m. on a Saturday night. At oh-dawn-thirty we were due to catch an airplane to Hawaii. And Big Cheetah was thoroughly dead.

Corpse Revival

It was probably a good thing that I had to catch a plane in the morning, because otherwise I'd have tried working all night, and I'd probably have made things much worse than they were. Still, I got out my emergency floppy disk, Startup Master, and put that in Big Cheetah's drive A and reset. Nothing happened.

By now, I was in a real panic. Rationally, I shouldn't have been. After all, everything up to late Friday evening was backed up on the WORM drive. True, what I'd worked on all day was probably lost, but heck, it wasn't *that* much, and

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besides, I could pretty well remember what it was I'd done. It wasn't as if I'd been doing creative writing—and yes, I know that sometimes programming can be quite creative, but what I'd been doing hadn't been like that at all, it was just file management stuff, easily recoverable work. All I'd lost was some time.

Still, I was annoyed, and while I didn't see how some software program could permanently harm Big Cheetah, he sure was dead, which was a little scary.

It was now about midnight. I called my son Alex. After all, he's in the data-recovery business. What's the use of having kids with degrees in computer science if you can't bug them in the middle of the night? Actually, he was up, since he keeps about as weird hours as I do.

"Have you looked at the RAM BIOS entries?" he asked.

I blushed to say I hadn't.

"Run the Setup program," he said.

"How can I do that when it won't even look at the floppy?" I muttered, but then I realized that with an Award BIOS, as Big Cheetah has, the Setup program is in ROM; all you need to do is press Ctrl-Alt-Esc during the boot-up sequence and you're automatically put into Setup. I did that.

"Nothing," I reported. "Every entry is blank. Even the time."

"That must have been some COPY utility," Alex said.

I reset the clock and told Big Cheetah that he had a 1.2-megabyte floppy disk in drive A, a 360K-byte floppy disk in drive B, and a "Type 9" 330-megabyte hard disk drive as drive C. Then I tried to boot up.

Big Cheetah looked at drive A, but since the door was open, he tried to boot from drive C. "Bad or missing Command file," I was told. Not good news, but at least we were making progress. I put the DOS 3.3 Startup Master in drive A and reset. Up he came. I couldn't access drive C, or any of the other hard disk drives for that matter, but at least I knew Big Cheetah was alive. At that point I went off to bed. Next morning I caught the plane.

Supercomputers

Hawaii was great. Not only was the conference extremely interesting, but by getting up at 5:00 a.m., while it was still dark, and going out on the golf course in my pajamas, I was able to see Alpha Centauri, the nearest star (and the origin of the Fithp invaders in *Footfall* by Larry Niven and Jerry Pournelle).

It used to be that the only supercomputers were at the National Weapons Laboratories, namely, Lawrence Livermore and Los Alamos. Then some really bright people got to thinking that even when supercomputers become more widespread, there won't be many people who know how to use them because there's no way students, or faculty members for that matter, could get any time on them. From those thoughts grew the National Science Foundation (NSF) Supercomputer Center program.

I am not normally a big fan of government programs. Most not only don't work very well, but they often produce more of the "problem" they were designed to solve. However: let me be the first to say that the nation nearly always benefits from the investments made by the NSF in general, and that the NSF Supercomputer Center program may be the most spectacularly successful government investment since Isabella hocked the crown jewels.

Indeed, if you've a mind to write letters to your Congresscritter, you might mention this program: that it has worked wonders, and the only problem now is that it was so successful that it's underfunded. It needs more resources to put more time in the hands of more people. More important, though, the whole point of the program is to make available the absolutely latest in supercomputer technology, and the Centers won't be able to do that and expand their grant program at the same time.

We're not talking about billions here. A hundred million dollars a year works miracles. And do understand, we're talking about *investments*, with real and visible payoffs. We don't have any U.S. equivalent of the Japanese Ministry of International Trade and Industry to help U.S. industry against overseas competition, and that's probably just as well: the last time the Department of Commerce got into the act to "help" with the DRAM-chip situation, they darned near ruined the industry. Consequently, the NSF grant programs, which enable our students and faculty members to stay out at the cutting edge of technology, are by a long shot our most effective weapons. They really are important, and they really do work miracles.

I got to see some of those miracles in Hawaii. What has happened is that while supercomputing is still confined to a fairly small community, that community has grown spectacularly in the past few years—and every scientific discipline that supercomputing touches gets revolutionized. Biology, hydraulics, aeronautics, physics; the list goes on.

There's still a lot to be done. There are real problems with operating systems

continued

and languages—most scientific work is done in FORTRAN, and as one physicist put it, after you've written 40,000 lines of FORTRAN, you're too tired to do physics any longer. There need to be software tools and easier user interfaces. Some of that is already happening, as for example at the Illinois National Supercomputer Center, where Director Larry Smarr has interfaced the supercomputers with all kinds of machines, including the Macintosh.

You Too Can Play

I'll have a lot more on supercomputers in the future, but for now, the news is that any legitimate student or faculty member of any U.S. university, college, or junior college who wants time on a supercomputer can get it.

Write Janice Friedland, User Administration Coordinator, John von Neumann National Supercomputer Center, P.O. Box 3717, Princeton, NJ 08593. Ask for either the Education Grant Form or the Research Institution Grant Form. The education grants are for 2 hours' time and are nearly automatic; they're for the purpose of getting familiar with supercomputers. The research grants go up to 20 hours, and they require a brief proposal for educational demonstrations or small research projects. Review is very rapid.

Janice Friedland can also be reached on Bitnet as FRIEDLAND @ JVNCC or on the Internet network as FRIEDLAND @ JVNCA.CSC.ORG.

Fill out the forms; if you're a student, get a faculty member to countersign; and the time is free. (You may have to pay for long-distance access, although many academic institutions are already connected through one or another network, and those may be free.)

Incidentally, the National Supercomputer Centers find it amazing that only 1 percent of the academic use of their machines is by computer science and mathematics departments. Most is by engineering departments, followed by physics. Biologists use more time than computer science departments.

Restoring Big Cheetah

Hawaii was fun, but I brooded all the way back, and although we got in late at night, I couldn't wait to work on Big Cheetah.

My first move was to get out Norton Disk Doctor (NDD), put it on a floppy disk, and see what it said about the hard disk drive.

The result was interesting. NDD reported a number of problems, including a damaged partition table, and it offered to fix them. I told it "thank you, no," until I could think it over. The surest way to recover any data off Big Cheetah's hard disk would be to let Alex have at it. Workman & Associates has been able to work miracles in data recovery, but it would be no favor to them to try home remedies first.

On the other hand, Alex is busy, and he wouldn't be able to get at it for a day or so; and after all, I did have WORM drive backup copies of just about everything on that disk. What the heck, I thought, and told NDD to go ahead.

It trundled for about a minute, then it asked me to reboot the machine. This time Big Cheetah admitted he had a drive C—and reported a bad copy of COMMAND.COM. That was easily fixed. By now, Big Cheetah was healthy enough to boot from a 1.2-megabyte floppy disk. I transferred the ESDI disk driver—with a 330-megabyte hard disk drive, you re-

continued

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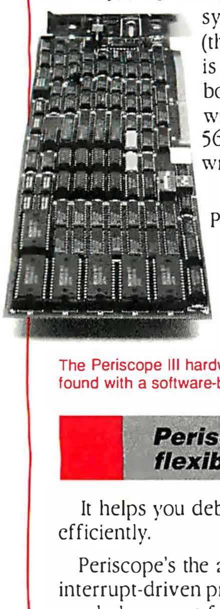


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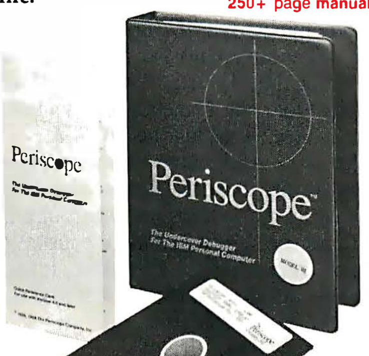
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quire a special driver that's loaded with CONFIG.SYS—booted up, and did a SYS operation to transfer the system and command file to drive C. After that, Big Cheetah booted off the hard disk. He still didn't believe he had drives D through L, but we were making progress.

I ran NDD again, and again I was told that the partition table was damaged. Once again I let NDD work on it. Lo and behold, drive D reappeared. Another iteration of NDD, and I had drives C, D, and E.

"Piece of cake," I muttered, and tried NDD again.

When the program finished this time, I had drives D through L—but *now*, Big Cheetah steadfastly refused to believe that drive C existed. Nothing I could do would change that. Drive C was gone.

There was worse news. The Maximum Storage WORM drive software has no provision for forcing the drive name to a particular letter. Instead, it automatically becomes the next available drive. When Big Cheetah is working properly, the WORM is drive M; but with drive C "missing," the WORM tried to be drive C, and since it knows it can't be that, it wasn't accessible at all.

Fortunately, my WORM is an external drive, and I have an extra controller card, so it was no trick to run it on the Zenith Z-386. Maximum Storage's installation software pretty well runs by itself. That done, I connected the Z-386's serial port to Big Cheetah's and ran LapLink on both. After that, I was able to peel off all my work from Big Cheetah to anywhere on the Z-386, including the WORM.

After that, Alex came over and managed to restore drive C. As he'd warned me, what he did lost drives D through L in the process. I grabbed off a couple of late files from drive C. After that, it was time to get out the Priam software and reformat the hard disk drive.

That went fine. Priam's latest software is supposed to work fine with DOS 4.0, which would let me do away with partitions and have one big 330-megabyte logical disk drive. (That way, the WORM would be drive D.) Next week, I may try that; but for the moment, I was content to reinstall DOS 3.3 and partition it into drives D through L again. Then I used the WORM (now drive M again) to restore everything.

The upshot was complete recovery. I have been using Priam hard disk drives since 1982, when Bill Godbout, after extensive analysis, decided they would be the best drives for his CompuPro 8/16 systems; indeed, I am still using that original 40-megabyte drive. There's a Priam drive in Mrs. Pournelle's Kaypro 386i, and we've had Priam drives in other systems. Now that Big Cheetah has been restored, I can once again report that I have never lost a single byte of data from a Priam hard disk drive. That's quite a record.

But That's COMMON

First things first. I wrote a large batch file to copy and rename the lesson and graphics files. That was actually a pretty simple job with Logitech's Point editor, which has an easy way to duplicate text. I just wrote COPY F:\QB\READ\LESSON.32 G:\READ\LESSON.31, then used Point to duplicate the line, duplicated the two lines just formed, and so forth until I had 32 copies. Then I adjusted the numbers in each line, duplicated the whole mess, substituted BANNER for LESSON in the second batch, and did all that again to get commands for the third set of files. Obviously, any other good programming editor, such as BRIEF, would have done the job as well. The whole thing didn't take 5 minutes to write, and not much more than that to run.

That put me back where I'd been Saturday night before we left for Hawaii.

There were more surprises. The program ran fine in interpreted mode. It compiled fine. What it wouldn't do was link in a couple of the Project X library modules.

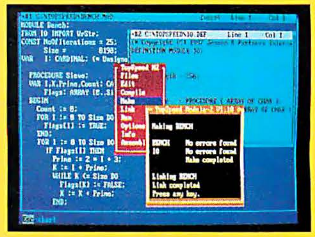
I cursed for a while. Then I went in and removed all their stuff. This forced me to write my own equivalents, which I did; that took me a lot less time than I'd thought it would, demonstrating once again that once you have the actual program structure right, coding is generally straightforward. It all ran fine in interpreted mode.

Of course, QuickBASIC 4.5 wouldn't compile it. This time, the error was

continued

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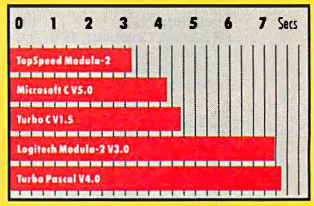




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Circle 143 on Reader Service Card

"Module Too Large." That one was simple to fix. I broke the code up into several modules and compiled each. Worked fine. Linked them. Worked fine. Ran the code.

"String Space Corrupt."

A *blooming wonder is what I consider Mathematica to be.*

If you look that up in the Microsoft reference manual, it tells you that you've probably made some kind of error in a COMMON statement. I had only one COMMON statement in the doggone program, and all it did was pass a number of universal constants, such as TRUE and FALSE. I could have experimented to see what was wrong now, but I didn't. It took only 5 minutes to rearrange modules so that I didn't need any COMMON statements at all.

Done!

Five minutes later I was done. Mrs. Pournelle's Reading Program is finished. There's about 100K bytes of code. I'll be able to trim it quite a bit by eliminating line numbers and other diagnostic hooks, downsizing arrays, and generally tightening things up; the program should run in a 256K-byte machine. At the moment, it takes about 340K bytes. It also requires either a color or a Hercules graphics monochrome video card.

There's still some polishing to do. The documentation is Mrs. Pournelle's problem, but she pretty well hammered that out in beta testing. I may add touches like help files. What we do have right now, though, is a stable program that will enable just about anyone who can read English to teach just about anyone else.

The highly structured program uses intensive sequential phonics. In addition to the program and a computer, there must be an instructor present to read the on-screen lessons and instructions. The instructor need not be a trained professional, or even an adult.

There are 70 lessons. Each takes a *minimum* of 20 minutes. (Since the program is self-paced with built-in rewards, we can't specify a maximum.) At a normal pace of one lesson a day, with reasonable time for weekends and review, that's 90 days to full reading ability.

Of course, it will take longer in special cases, and we suppose there must be cases (particular pupils or combinations of instructor and pupil) where it won't work at all—although we've never seen one. It does take patience and persistence, but then, all education does.

Mrs. Pournelle's Reading Program (IBM PC version 1.0) is available from Roberta J. Pournelle, 3960 Laurel Canyon Blvd., Suite 372, North Hollywood, CA 91604. The current price is $100 postpaid. We haven't the remotest idea of what the final price will be or, for that matter, who the publisher will be.

Winding Down

I'm writing this on the SupersPort 286 in the San Francisco Hilton. We're up here for the annual meeting of the American Association for the Advancement of Science, followed by MacWorld Expo. A lot of exciting things are happening in the world of science. One that's particularly relevant to computer users is Mathematica from Wolfram Research. As of this week, there's an 80386 version, as well as versions for the Mac and the NeXT machine. The program is a blooming wonder. More on it next month.

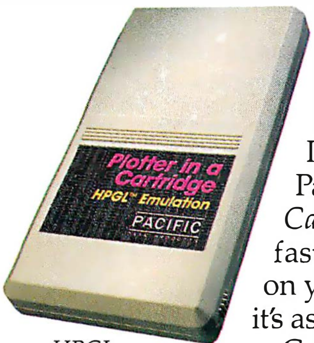
The book of the month is Edith Efron's *The Apocalyptics* (Simon and Schuster, 1984). This is a long but fascinating scientific detective story that should be must reading for anyone intelligently concerned about environmental quality, which, I hope, means every voter. As Efron says, laypeople can't make scientific judgments; but we do have to understand the costs and benefits of rules and regulations.

Now I have to get back to MacWorld Expo. Tonight, we drive back to Hollywood. I confess I can't wait to get back. I've thought of a couple of final touches that I can put on Mrs. Pournelle's Reading Program, and I want to play with Mathematica. ■

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on BIX as "jerryp."

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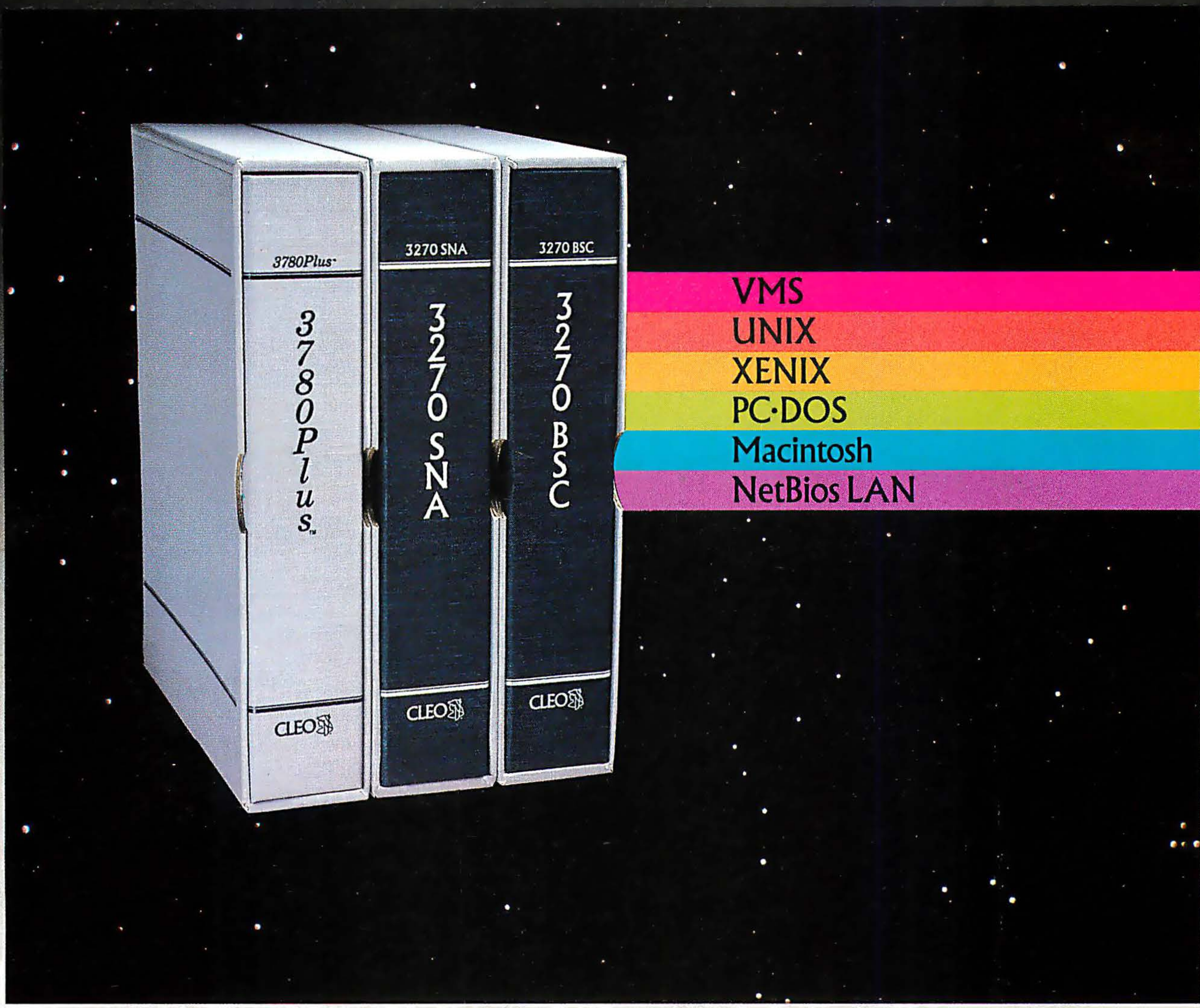
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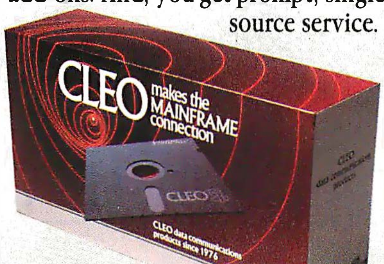
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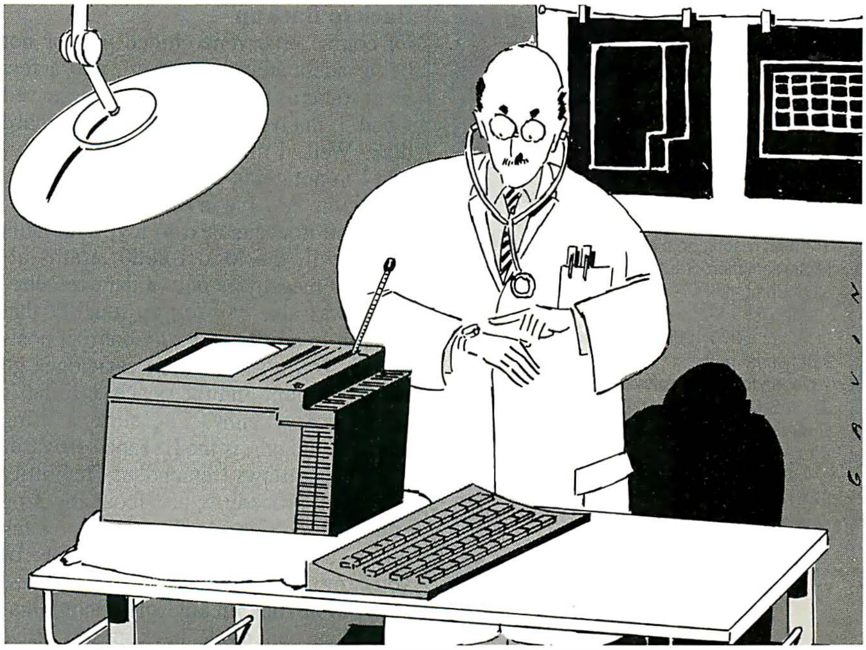
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ANSWERS TO MY MAC MESS

Readers rise to defend the Mac and offer solutions to system snafus



In my December 1988 column, I commented that my Macintosh system had become as overburdened and fragile as my MS-DOS system, with frequent crashes and the accompanying sense of insecurity and fear. I pin this problem on a number of factors.

First, there is the proliferation of INITs and cdevs, programs that are loaded at boot-up and modify the available functions of the operating system. Many of these programs are essential to me (e.g., Vaccine, a public domain virus-protection program, and QuicKeys, the keyboard macro program from CE Software), but they occasionally conflict with application programs, the operating system itself, and each other.

Second, Apple's upgrades to the operating system are often somewhat buggy. The maintenance releases that follow major overhauls seem to fix most of the problems, but invariably Apple also changes the rules for software compatibility just enough to make using older applications a risky proposition.

Third, the pressure to bring new products to market sometimes forces developers to release programs before they're thoroughly debugged.

Finally, the increasing size of programs and the dangers of negotiating the minefield of conflicts with other products make bulletproof debugging nearly impossible. Sooner or later, no matter how exacting a vendor's quality-control procedures, some customer somewhere will come up with a set of INITs, desk accessories, and other programs running under MultiFinder that will bring the system to its knees.

I don't blame anyone for this mayhem, and it's certainly not unique to the Mac universe. I note that Apple and the community of Mac developers have done a good job compared to the confusion that infected the MS-DOS world when memory-resident programs appeared. However, my complaining sparked a spate of correspondence on the subject.

Safe Strategies

One group of letter writers offered a practical solution to my headaches: Don't upgrade the operating system or applications until you're absolutely sure that everything will run amicably. This is really the only strategy that makes sense; and I endorse it wholeheartedly, whether you're running a Mac, an IBM PC, a VAX, or anything else.

If you can possibly do it, stay one or two releases behind the most current offerings and let other people serve as the guinea pigs. Unfortunately for me, it's my business to act as a guinea pig, and thus I consciously place myself in jeopardy with more willingness than I would were I merely using software rather than evaluating it. I stick my neck out lest others get their heads chopped off.

Other correspondents took umbrage with my bashing of Apple's System software releases as "more bug-laden and crash-prone than Microsoft's MS-DOS updates." I stand by the point, but it's really immaterial; the evil synergy occurs when a number of components are in contention. Even if the Mac operating system was completely solid, which I dispute, the hassles arising from running the mélange of operating system, MultiFinder, new applications, old applications, desk accessories, INITs, cdevs, and so on, stem from the interaction rather than any one piece of the puzzle.

The best advice is to test each component independently before attempting to incorporate it into a complex environment. By being careful and testing exten-

continued

sively, wrote Matthew Dixon Cowles, "I have not, by any means, had to become 'accustomed to the sporadic system crashes that characterize life on the Mac.' And neither have my clients."

OK, fine. I yield. If you adopt a conservative approach, you'll be safe. If you want to waste your time testing every piece of software you own, singly and in combination, or hire a consultant to do the same thing, that's your business. Me, I think this says something about the nature of personal computing these days. Something ugly.

Back to Backup

Of course, everyone chided me for not being adequately backed up, and a few went so far as to say I got what I deserved when I inadvertently trashed my hard disk. Well, I'm not entirely foolhardy, and I'm not going to get caught again. A handsome new Irwin Magnetic Systems' tape unit now sits next to my Mac. This little devil, the Model 5080, crams almost 80 megabytes onto a data cassette, and I was able to back up roughly that amount in a little under an hour. It costs $1695, Irwin's formatted cartridges go for $35 a pop, and the peace of mind is worth every penny. The slickest thing about it, though, is the EzTape software.

EzTape allows tremendous flexibility in backup procedure; just about anything you want to do is possible. You can back up or restore an entire disk volume, or you can specify folders, individual files, or types of files, in any sort of combination. You can name backup sets, save rule criteria as parameter files, and perform incremental backups by date or by date of last backup.

The program will run in the background under MultiFinder, and you can configure it to run automatically at a certain time or regularly at a specified period. It will even restore MS-DOS tapes to a Mac disk, or vice versa. (When acting as a file transfer system from Mac to MS-DOS, EzTape will discard the meaningless Mac resource forks and create legal filenames and directory names.) In the past, I've used HFS Back Up, Diskfit, and Central Point Software's PC Tools backup module. This program is as good as any of them.

If you're going to attempt unhealthy maneuvers in an environment that's not rock solid, buy some insurance.

Good-bye, Mousie!

My search continues for an acceptable alternative to the mouse. This month's entry is the MouseStick from Advanced Gravis Computer Technology, a deluxe joystick that lists for $169.95. I've been experimenting with the Mac Apple Desktop bus (ADB) model, but other versions are available for older Macs, the Apple IIGS, and PC compatibles. It's a nifty gizmo, well built and responsive, but I've had a few trivial snags that temper my otherwise enthusiastic endorsement.

The unit itself is a bit more complicated than I would have expected. A 4-inch contoured, foam-padded stick rises from a base that's 6½ inches wide, 4¾ inches deep, and 1¼ inches high. The base has rubber feet; that fact, along with its size and weight, makes it difficult to tip in most situations. With the two large thumbwheels front and rear, you can adjust stick tension from stiff and springy down to totally limp. There are three "fire" buttons, two on the base to the left of the stick and one on top of the stick. All three buttons are initially set to generate single mouse-clicks.

A cable leads from the pedestal to another box, about a third smaller than the base, which houses the device's programmable electronics. A 16-character LCD indicates mode settings that enable nearly total control of resolution, tracking, and button function. An ADB cable leads from this GMPU (Gravis MouseStick Processing Unit) to the Mac.

continued

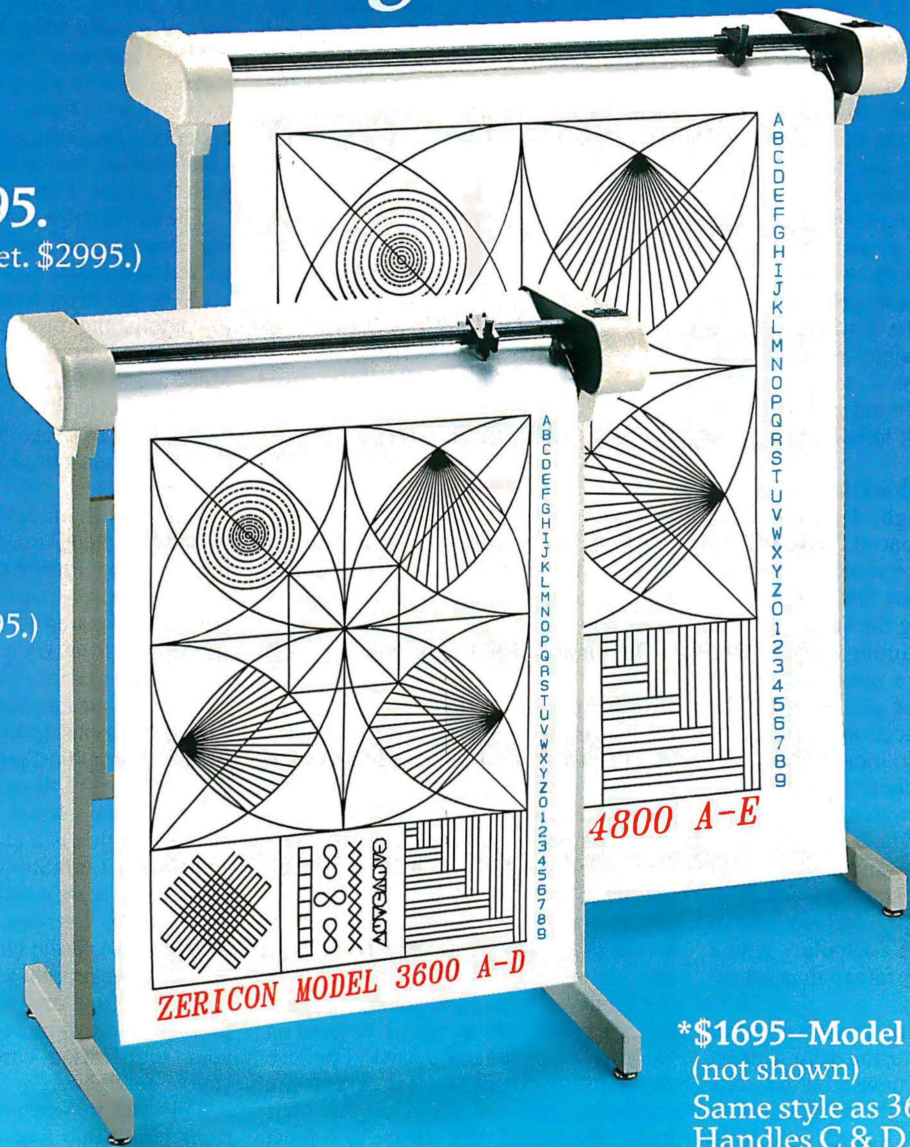
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After I had used it for a few minutes, I was convinced that my instinctive approach to the MouseStick, which was to grab the stick in my fist and click the top button with my thumb, like a jet pilot, was useless for anything but game playing. You need far more precision for even the simplest Mac operations, like clicking on an icon or setting the cursor; I felt about as coordinated as someone trying to fill out tax forms with one of those fat crayons they give you in grade school. I had also adjusted the joystick for the highest level of tension, figuring that would give me the fastest, most sensitive response. Instead, I found myself struggling against the stick to hold the cursor in position.

By thoroughly rethinking the way I held my hand, though, I was able to achieve a degree of control I have not experienced with either a mouse or a trackball. Resting my index finger on top of the stick and grasping the shaft between my thumb and remaining fingers, the way you might hold a saltshaker to tap out small quantities of salt, gave me the ability to make tiny, accurate movements with the cursor. I also loosened the tension wheel five notches, to the lowest amount of spring allowable for automatic centering.

Using Aldus FreeHand and Cricket Paint, I actually knocked out a couple of drawings as close to pen and ink as I've ever produced with a computer. And I could sketch quickly, rather than laboring over every line.

With the mouse, you draw with your shoulder and elbow, using your fingertips only to click the mouse button. The trackball cuts down the large muscle movements, but there's still very little wrist involved, and the second gesture necessary to click a button is often awkward and throws off your cursor position. The MouseStick puts it all in your wrist and fingertips; it's very tight and very comfortable. I haven't had enough experience with a stylus and a bitpad to make a knowledgeable comparison, but I'd guess that a skilled MouseStick operator could come close to the effects achieved with a digitizing tablet.

Now for the bad news. The GMPU draws its power directly from the Mac's ADB; there's no internal battery. Any configuration settings you program into it are wiped out when you turn off the Mac. Though running through the setup routine every time you boot the computer is inconsequential, it's irritating. This is pretty dumb; a little bit of RAM and a lithium battery are not too much to ask at this price.

Further, the unit is designed for the game player who wants to play rocket jockey, so even if the MouseStick is built for abuse, the ergonomics don't favor the serious computer user. I'd love to see a reworked MouseStick with a slimmer base, a shorter shaft, and a convenient way to rest your wrist on your work surface.

I've never been particularly opposed to copy protection.

But for now, I'm very pleased.

Bitten Again

Just when I thought it was safe to go back into the water, I was attacked by that old nemesis, the copy-protection shark. This happened three times in the course of a two-week period, which was quite a surprise. Copy protection has pretty much vanished, particularly in the category of business software, so finding three protected programs all at once is worth a few comments.

I've never been particularly opposed to copy protection; in fact, I've gone on record as something of a hawk. I believe that software companies and authors are entitled to just compensation for their work, and should they choose to combat unauthorized distribution via copy protection, so be it.

Software piracy is rife; almost everyone I know engages in casual swapping on a regular basis. And coping with the various protection schemes is a petty annoyance that has been blown vastly out of proportion. Plugging in a key disk or running through an installation procedure is a momentary hassle at worst. On the other hand, a petty annoyance is still an annoyance. As a user, I choose to avoid the issue by steering clear of protected programs. This is what's known as a "marketing reality." Most vendors have chosen to acknowledge this attitude and unprotect their programs.

Two of the three cases I discovered can be dismissed easily. One was a game that merely requested I type in a certain word from the manual. Rather mild stuff, and certainly reasonable. The second was a $5000 package that's normally sold as part of a fully integrated system; it required a hardware key (what's known as a *dongle*) to be plugged into the Mac's modem port. I figure that if the consumers of this product are willing to pay that kind of price, they'll be willing to put up with this kind of nuisance.

The third case was much more disturbing, because the copy protection is attached to a major software package that could be one of the most significant desktop publishing products of 1989. The software is Letraset's LetraStudio for the Mac, a $495 typographic manipulation program that lets you kern, distort, color, and otherwise make headlines perform tricks you didn't think were possible on a microcomputer.

The resulting modified type is stored in Encapsulated PostScript format, ready for inclusion in files created by most word processing and page layout programs. Compared to the dismal effects you get when you try to blow up standard PostScript-text alphabets to headline size, this is spectacular stuff. Anyone involved in serious desktop publishing, advertising, graphics, package design, and so on will be drooling for this one.

LetraStudio itself is not copy-protected, but this is a classic case of razor and blades. LetraStudio is the razor; because it can work only with special typefaces sold by Letraset, the typefaces are the blades. And the blades are copy-protected. Four reversible installations, but protected. You get two blades with the package and two more when you send in your registration card—anything else you've got to buy.

This hits my fence-straddling position right smack-dab where it hurts. I can't really complain about this scheme on moral or ethical grounds, because I believe Letraset has the right to protect its interests however it sees fit. On the other hand, I need and want this program, and I also want lots and lots of blades for it. While I have never had a single disk mishap due to this sort of protection, these typefaces will be the only things on my hard disk that are copy-protected. Which makes me very, very nervous.

Something to think about, you bet. ■

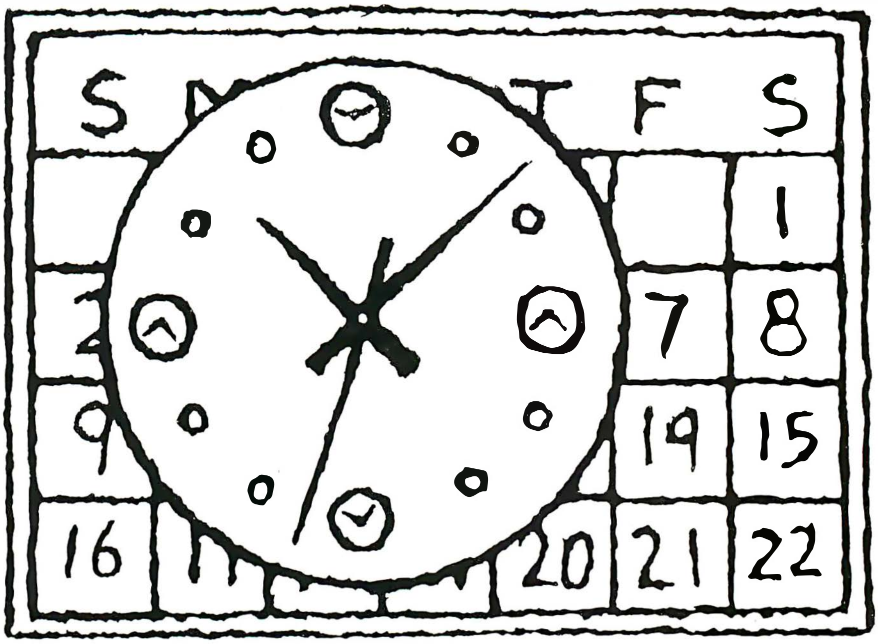
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Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.



GROPING FOR GROUPWARE

Group productivity software is designed to make life a little less complicated for busy executives



Group productivity software, or "groupware" as it's affectionately known, is designed to enhance the functioning of a group in much the same way that individual productivity software helps the individual. The difference is that groupware, to be effective, must enhance the interaction of the people in a group.

Because of the nature of a group of people, groupware faces several challenges. First, people who work together are not necessarily located together. They can be spread across many floors, between buildings, or even in separate cities. Second, a group consists of individuals who may have their own ideas about what work they need to do and how it should be accomplished.

The Parts of the Group

People in a working group interact with each other in two ways that software can help. The first is simple communications. This function is met through the use of a telephone or by E-mail. People also tend to gather in meetings, so they need to set up those meetings. An electronic scheduling package can help.

E-mail is reasonably familiar to most computer users. A good E-mail package should be easy to use, even for inexperienced users, but still capable enough that you can use it to forward word processing and graphics files. It should also allow time and date stamping, multiple addressees, copies, and forwarding. Mail should be password protected, so that someone else cannot send mail while pretending to be you.

An electronic scheduler allows group members to see when others in the group are free. It should have some way of notifying others that you want to have a meeting, and it should be able to automatically find a clear time for all members of a specified group so that they can schedule a meeting. Of course, the ability to do this doesn't mean that it can be used in every case. Not everyone likes to have others schedule his or her meetings.

Looking at Groupware

For this column, I looked at two packages of group productivity software: WordPerfect Office from WordPerfect Corp., and Higgins from Conetic Systems. These are designed to work on a LAN and to support the users on the network. Higgins has been around for years and is widely used, while WordPerfect Office was introduced only last year.

Both packages provide E-mail and group scheduling and are designed to provide a shell from which you can perform most other functions, such as word processing. Each contains additional productivity tools designed to make the busy executive's life less complicated. Whether they do this for you depends on whether your life matches what the company thinks it should be.

I used both packages on an Ethernet network running Novell NetWare 2.12. Both packages are designed to run on most other common LANs, including 3Com, Banyan, and most NetBIOS-compatible networks. Both packages reside on the file server.

WordPerfect Office

WordPerfect Office is the latest entry in what seems to be WordPerfect Corp.'s continuing effort to take over the world. The package is based on a shell that has a two-column screen of choices (see photo 1). Along with the shell, you run a small memory-resident program that will alert

continued

you when it receives mail messages or schedule requests.

The standard shell that comes with WordPerfect Office includes choices for all the included groupware programs, as well as for WordPerfect, PlanPerfect, and DataPerfect (not included; you can easily change the entries for these if you don't have that software). The shell lets you create a menu with up to 20 entries and provides a command line that lets you run anything else you need. For example, you need the command line to perform DOS functions, since none of these are provided on the standard Office menu. Of course, you can add them to the menu yourself, if you wish. The shell requires only about 40K bytes of memory, and it didn't seem to interfere with any other software.

When the shell loads, it is able to tell who you are from the network software, so you don't have to enter your name again, though you do have to enter passwords for the mail and scheduler systems. Otherwise, you can remain in the shell and perform your day's work.

In addition to the scheduler and E-mail, Office contains a calendar program that works in conjunction with the scheduler. This means that people can see whether you're busy, but they can't see the details of your calendar or who you're meeting with. Office also includes a file manager, which lets you search for and copy DOS files; the Notebook, which is a flat-file data manager; and a calculator. There is also a macro editor for WordPerfect and a program editor for batch files and the like. For those long lunch hours, Office also contains a game called Beast. which is nice, but not nearly as nice as Novell's multiuser Snipes game.

WordPerfect users will feel right at home with WordPerfect Office. Most of the common keystrokes are the same, and the flow of the program is familiar. The editors are quite similar to WordPerfect. The E-mail editing screen follows a message format, but most of the familiar WordPerfect keys work there, too.

Higgins

When you start running Higgins, it lets you know right away that it's groupware: The first thing you see is the group scheduling screen (see photo 2). Other functions appear in windows on your screen, but your calendar is always right there at the top. If you have a busy schedule that you need to refer to a lot, this is really handy.

Likewise, Higgins shines when it comes to E-mail. You can buy optional packages that let you send mail to external systems, to other networks, and to mainframe mail systems. You can even send mail to people who don't have E-mail: If you specify it, Higgins will print the mail message so that you can send it via paper mail.

At the bottom of the screen, a Lotus-like menu gives you access to several applications. Higgins includes additional productivity tools in the form of a calculator, a scratch pad, and an expense program. The expense program seems to be useful, though many companies require specific software or expense voucher forms that would limit the usefulness of the software contained in Higgins.

Unlike WordPerfect Office, Higgins doesn't let you incorporate specific external software into the menu system. Instead, you invoke a command that *gives* you a command line from which you can run external software. This makes Higgins somewhat less convenient for inexperienced users.

If Higgins has a problem, it's security. When you start up Higgins, it asks you for your name and password. It does not take your name from the network software. Once you enter the password, you need not do it again. This means that if you are going to be away from your desk, you need to leave Higgins, since anyone with access to the computer could enter your mail and scheduling system. WordPerfect Office, on the other hand, requires you to enter a password each time you access mail and scheduling. This means that you can start up the Office shell and stay there all day, since you can run software from there and since others still won't have access to your mail and schedule systems.

On the other hand, Higgins will allow you to have two passwords for your account. You can have one for yourself that allows full functionality and another with partial functionality for your secretary. Higgins also lets you arrange for your nonprivate mail to be forwarded to someone else while you're away.

In general, Higgins is easy enough to operate, although I did find it awkward to use the space bar, rather than the arrow keys, to navigate through the Lotus-like menus.

Grouping the Differences

I found both packages useful. WordPerfect Office suited me better, but as in the

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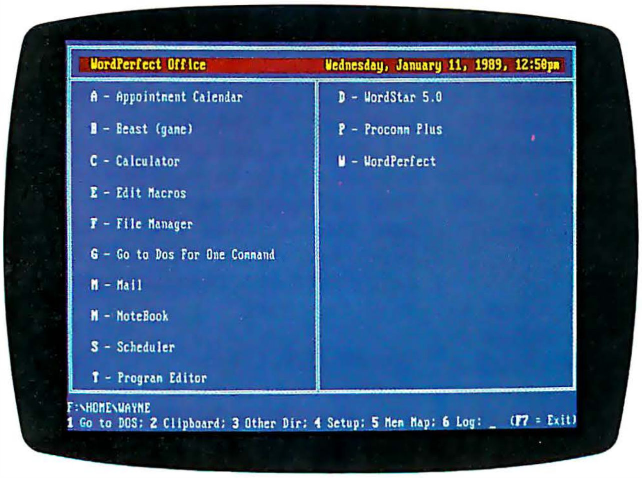


Photo 1: *WordPerfect Office's menu lets you choose from several built-in programs or create menus of up to 20 choices from your own application programs.*

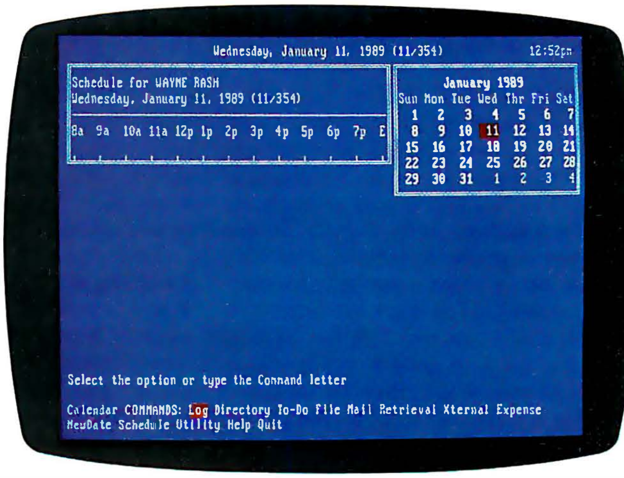
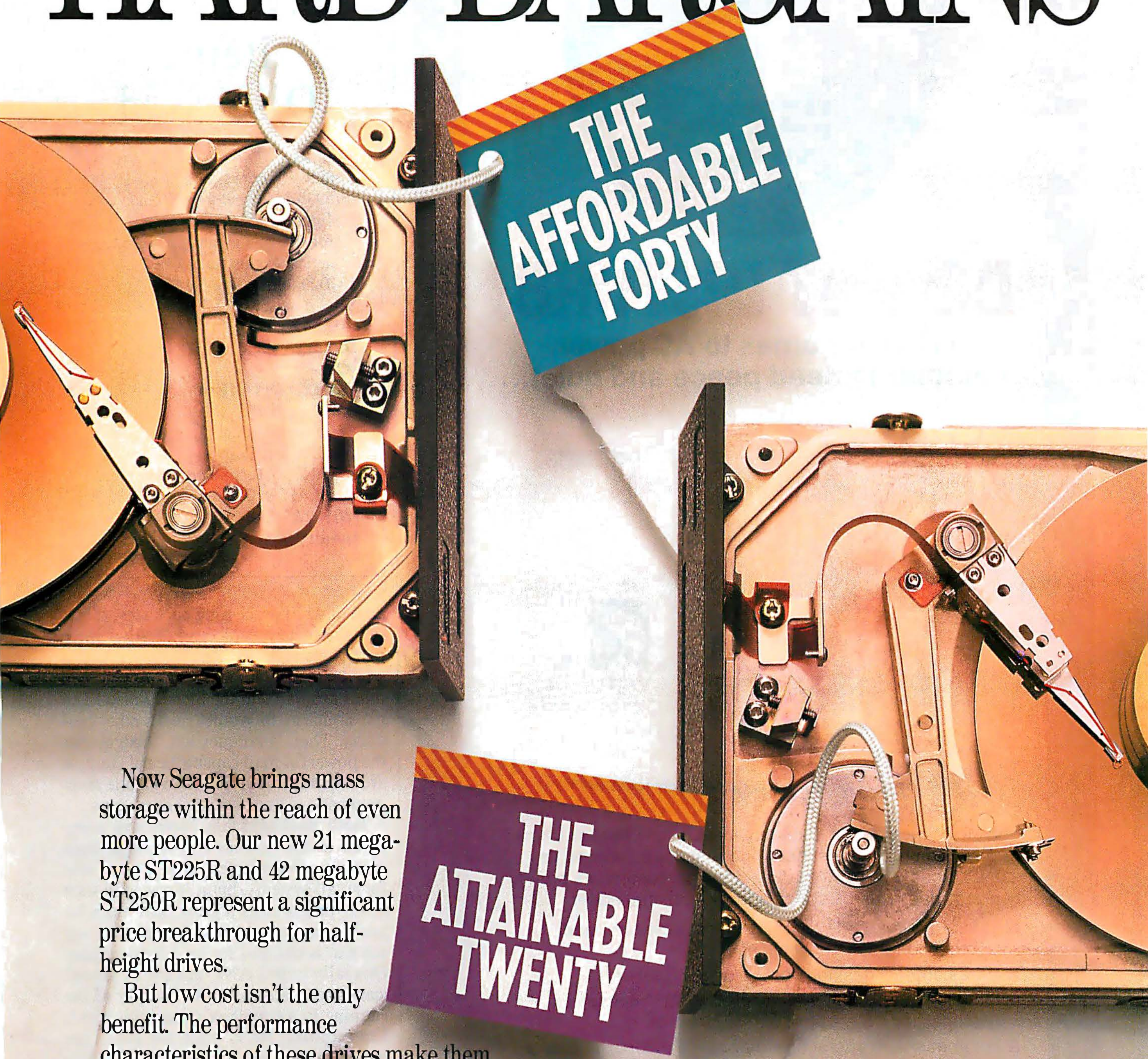


Photo 2: *Higgins places the group scheduling window prominently on the screen and includes a Lotus-like menu at the bottom that gives you access to other applications.*

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case of word processing packages, this is to some extent subjective. Still, I liked being able to load the shell once and let it stay there all day, and being able to add other programs to the menu. I also liked the similarity to WordPerfect's other products. There's no question, though, that the powerful mail capabilities of Higgins are important if you need to handle communications over a variety of systems.

Both packages are expensive compared to the normal run of single-user software. WordPerfect Office costs less for small systems, but it is priced in such a way that it costs a great deal more for really large systems, because a set amount is charged for each workstation. On really large LANs, this can be significant and has knocked Office out of the running in a couple of cases with which I'm familiar. As is often the case, you probably get what you pay for, but there is the question of whether you need all of what you're getting. ■

Wayne Rash Jr. is a consulting editor for BYTE and a member of the professional staff of American Management Systems, Inc. (Arlington, VA). He consults with the federal government on microcomputers and communications. You can reach him on BIX as "waynerash," or in the to.wayne conference.

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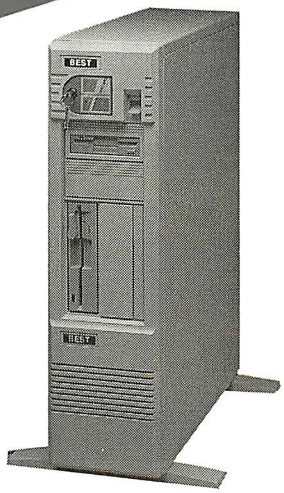
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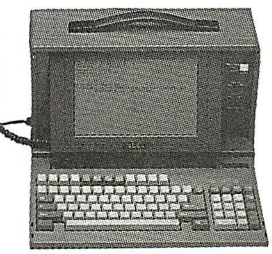
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SMALLTALK CAN BE CHEAP

Smalltalk/V Mac could be a cheaper alternative to Smalltalk-80



Regular readers of this column know that I've become a convert to ParcPlace Systems' Smalltalk-80. I've been using that system for more than half a year now and I'm impressed with its abilities at ad hoc programming.

A couple of things have bothered me about Smalltalk-80, however. The first problem is its price: a budget-blowing $995. I am trying to put together a Smalltalk course for next year, but Smalltalk-80's steep price tag is a big impediment to that. I simply can't afford to buy the 30-plus copies I'd need. A possible solution might be educational discounts and site licenses.

The second problem is Smalltalk-80's non-Mac interface, which I'll cover in more detail in a moment. Recently, another version of Smalltalk for the Mac, called Smalltalk/V Mac, from Digitalk, Inc., of Los Angeles, hit the market. Digitalk already has a PC version of Smalltalk/V available, and the new Mac version is source code–compatible with it. I've spent the last two weeks testing Smalltalk/V Mac, comparing it with Smalltalk-80, forming some early opinions about this language implementation.

First, Smalltalk/V Mac is quite a bit cheaper than Smalltalk-80 at only $199 per copy. Second, Smalltalk/V Mac follows the Macintosh desktop interface much more closely than does Smalltalk-80. Smalltalk-80 uses an interface that's nearly identical to all the other ParcPlace Smalltalk-80 implementations on Sun workstations, among others.

Smalltalk V/Mac works and feels more like a Mac application, while Smalltalk-80 works and feels more like a Unix workstation application. And Smalltalk/V Mac proved to be much easier to install and learn than Smalltalk-80, largely because of these interface differences.

For example, *prompters* are the methods by which Smalltalk interacts with the user or an application. Smalltalk-80 uses the traditional prompters, implemented directly in Smalltalk code as Smalltalk classes within the Smalltalk-80 environment. Smalltalk/V Mac implements prompters as Macintosh dialog boxes, preserving both the Macintosh interface and the prompter's Smalltalk functions.

In many ways, like the prompter, Smalltalk/V Mac implements standard Smalltalk features by using Macintosh pull-down menus, dialog boxes, and alert boxes. Smalltalk-80, instead, keeps the same interface across processors, so you never need to use the Macintosh menu bar unless you want to quit, invoke a desk accessory, or jump to another application under MultiFinder.

Beyond ease-of-learning issues, these interface differences could have serious consequences for software developers. If you plan to do significant cross-machine development, the ParcPlace system is likely to be a better choice, with its consistent generic interface.

Both Smalltalk systems separate the virtual image (containing the Smalltalk-80 language and compiler, the run-time system, graphical system libraries, and program development tools) from the virtual machine (which links the operating system and hardware of a particular computer to the virtual image). ParcPlace takes this separation to its logical end by producing virtual machines that run on Sun-2, -3, and -4 workstations, Hewlett-Packard 9000s, and Apollo 3000 and 4000 workstations running Unix. ParcPlace also expects to release a DOS-based version for 80386-based sys-

continued

ILLUSTRATION: MARK MOSCARILLO © 1989

Listing 1: *Pascal code to count the frequency of alphabetic characters, from the Smalltalk/V Mac manual.*

```
Program frequency;

const
   size=80;
var
s: string(size);
i: integer;
c: char;
f: array [1..26] of integer;
k: integer;

begin
  writeln ('enter line');
  readln(s);

for i:= 1 to 26 do
  f[1] := 0;

for i:= 1 to size do
  begin
    c :=
      asLowerCase (s[i]);
    if isLetter(c) then
      begin
        k := ord(c) - ord('a') +1;
      f[k] := f[k] + 1;
      end;
    end;
for i := 1 to 26 do
   write (f[i],'');

end.
```

Listing 2: *Smalltalk code that performs the same operation as the code in listing 1.*

```
|s c f k|

f := Array new: 26.

s := Prompter
   prompt: 'enter line'
   default: ''''.
1 to: 26 do: [:1|
   f at: i put: 0].
1 to: s size do: [:1|

   c :+ (s at: i) asLowerCase.

   c isLetter
      ifTrue[
     k := c asciValue - $a
          asciValue +1.
     f at: k pt: (f at: k) +1
     ]
].
↑f
```

tems soon. So far, Digitalk's Smalltalk/V is available only for the Mac and the PC.

Different Approaches

Besides the interface, there are also differences in what each system provides and requires. The ParcPlace system provides many more utilities and sample objects to study, requiring six 800K-byte floppy disks and over 4 megabytes of hard disk space (once installed) to hold all the goodies. Digitalk's system needs only two 800K-byte floppies (some files are compressed with a special "compressor" application) and about 1.8 megabytes of hard disk space for installation, and lacks some of the ParcPlace utilities and samples. Both systems really need at least 2 megabytes of RAM, although the Smalltalk/V system can limp by on as little as 1 megabyte under the Finder. Smalltalk/V will also work with the Mac's RAM cache on; Smalltalk-80 will not.

Both systems are well-behaved under MultiFinder, so long as there is enough memory to go around. In my tests on an 8-megabyte color Mac II, I seldom ran into problems. Smalltalk/V Mac supports the Mac II's and IIx's math coprocessors via SANE (Standard Apple Numeric Environment) traps; Smalltalk-80 makes no mention of this support.

From my point of view, the biggest and most important difference between Smalltalk-80 and Smalltalk/V Mac is its orientation. Smalltalk-80 is presented as just one implementation of the Smalltalk-80 system that works across a variety of processors in a number of operating environments. Smalltalk/V Mac doesn't make these broad implementation claims. The Smalltalk/V package is much better geared for a quick understanding and exploration of Smalltalk than is the Smalltalk-80 package.

With Smalltalk-80, I found that three months of use had given me barely enough expertise to create simple programs, much less anything approaching a stand-alone application. In short, I was finding the learning curve pretty steep going, largely because of the way Smalltalk-80 provides its own self-contained environment. It was tough for me to intuit actions because I couldn't fall back on my knowledge of other Macintosh languages and development systems. This knowledge was quite useless as I learned Smalltalk-80.

Smalltalk/V Mac got me into the system faster (some of this learning improvement, of course, is certainly due to my accumulated Smalltalk-80 knowl-

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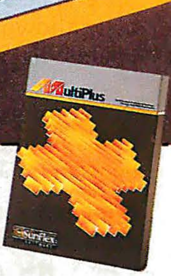
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edge) and it was easier to figure out what to do next, since I could rely on the Macintosh menus across the top of the screen. With Smalltalk-80, I had to keep referring back to the manual, or, through trial and error, try to remember which combination of mouse clicks and Shift-Option-Command keys was needed to activate a particular pop-up menu.

Even window scrolling was easier to learn and use with Digitalk's Smalltalk/V Mac since its windows use standard Macintosh horizontal and vertical window scroll bars. In short, the Smalltalk/V Macintosh interface was easier to master than Smalltalk-80's generic workstation interface.

Perks for Programmers

The tutorial examples provided with Smalltalk/V Mac are better suited to an old procedural programmer like me. The examples often give you a side-by-side comparison of a Pascal routine next to the solution implemented in Smalltalk. This kind of side-by-side comparison is invaluable if you're learning object-oriented programming (OOP) and Smalltalk for the first time and already have

> ***W**hat compromises were made to Smalltalk/V to keep it so small?*

programming experience with procedural languages like Pascal.

Here's a short sample taken from the Smalltalk/V Mac manual that illustrates the point nicely. One side of the page lists a simple Pascal program for counting the frequency of each alphabetic character in an input stream, as shown in listing 1. On the manual page opposite the Pascal listing is the equivalent Smalltalk program (see listing 2).

Both the Pascal and Smalltalk programs use predefined routines (Pascal used functions, Smalltalk used objects), called `asLowerCase` and `isLetter`. Both Smalltalk-80 and Smalltalk/V Mac can use primitives similar to `asLowerCase` and `isLetter` written in other computer languages. However, any Mac Pascal development system would be hard pressed to incorporate library code written in Smalltalk.

Smalltalk-80's manual does not provide these kinds of tutorial examples. Instead, it focuses more on a pure programming-language learning approach to OOP and Smalltalk. For me, the Smalltalk/V approach was easier to follow, but it could be less so for new programmers. They could very well favor the purer environment and teaching method adopted by Smalltalk-80.

My evaluation of Smalltalk/V Mac is too preliminary to tell if it could substitute for Smalltalk-80 in my planned Smalltalk course and in my own Smalltalk exploratory programming work. I'll need to learn a lot more about the Smalltalk/V environment and figure out the compromises made to keep it so small and inexpensive. One thing's for certain: the Smalltalk/V documentation is much better suited for the course I have in mind, composed of second-, third-, and

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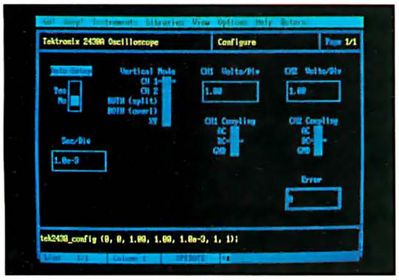
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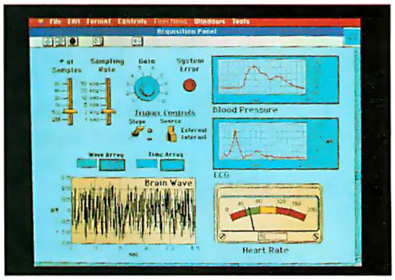
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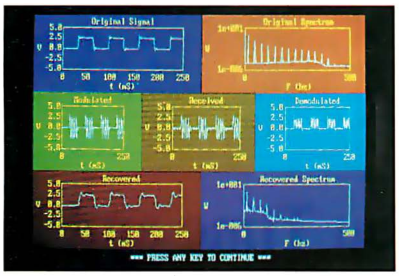
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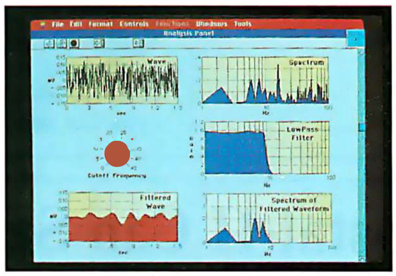
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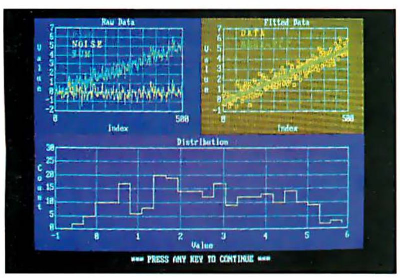
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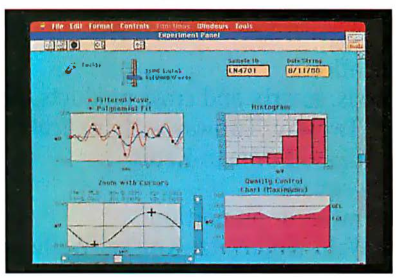
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fourth-year undergraduates. The ParcPlace Smalltalk-80 manual would likely overwhelm them.

MultiDisk: Disk Partitioning Utility

Last month, I mentioned that I would periodically discuss some of the best utility programs that I've stumbled across. One of these handy programs is MultiDisk, a useful and inexpensive little disk partitioner from ALSoft, a company that makes several useful utilities, including Font/DA Juggler, and my favorite, MasterJuggler.

MultiDisk works like other Macintosh disk partitioning programs, allowing you to create smaller logical volumes out of large hard disks. Such partitions help you use disk space more efficiently, keep Finder operations (like file copying) speedy, and protect you from data loss due to damage to the volume directories.

But MultiDisk combines some special features that I haven't found on competing products. Among these are noncontiguous partitions (i.e., disk partitions don't need to occupy contiguous free disk space) and expandable partitions (you can make disk partitions larger without having to erase and then recreate them).

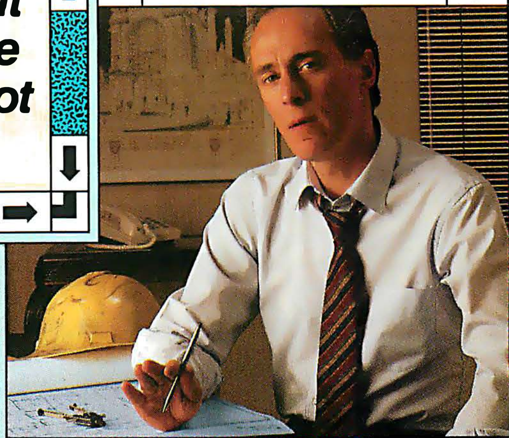
Individual features that I've found elsewhere, but usually not all together in a single partitioner, include: partition password protection and full partition encryption, desk accessory access to partitions, and TOPS and AppleShare network accessibility of partitions. MultiDisk partitions have all the usual Finder features that are associated with normal physical volumes, so they are very easy to manage.

MultiDisk does a great job at a good price. I can't wait for ALSoft's next utility. I'm sure that once I have it, I'll find that I can't live without it. That's certainly been the case with MasterJuggler and MultiDisk. ■

Don Crabb is the director of laboratories and a senior lecturer for the computer science department at the University of Chicago. He can be reached on BIX as "decrabb."

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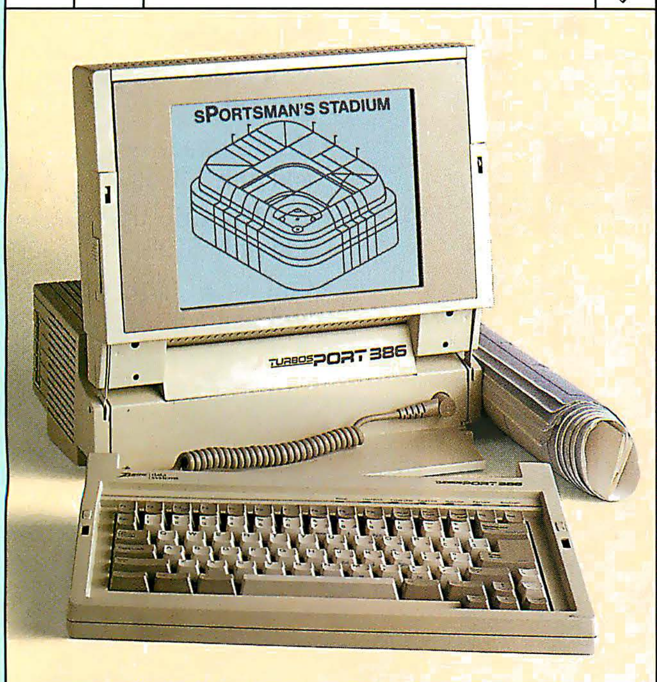
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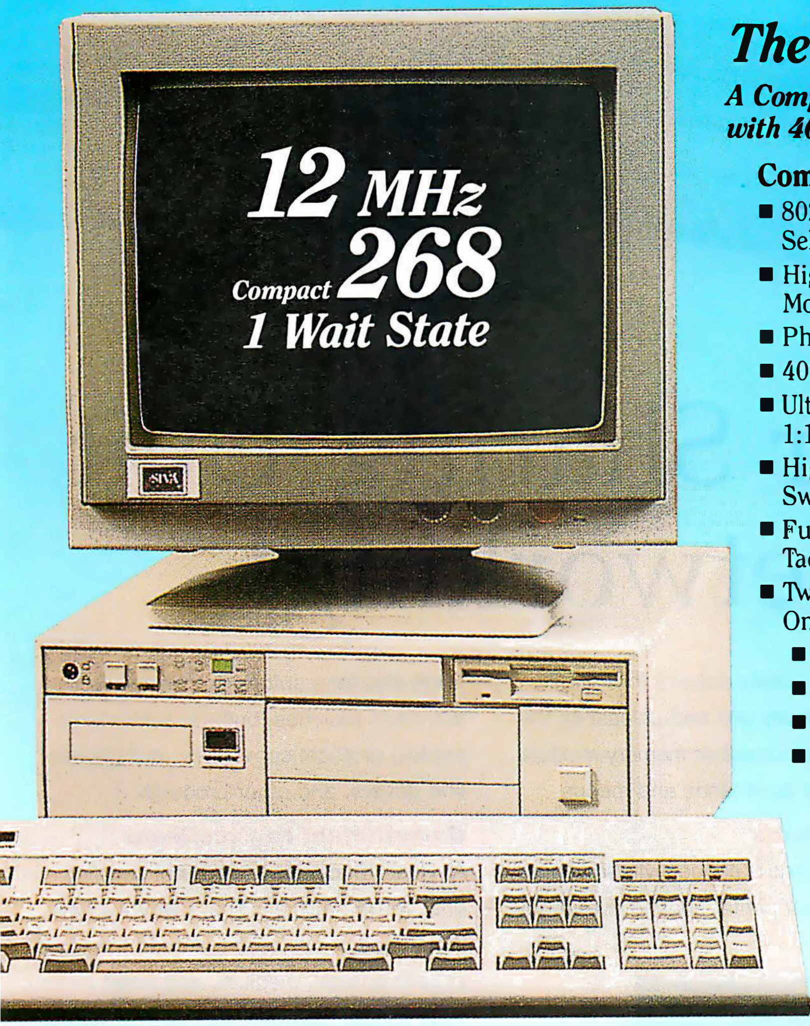
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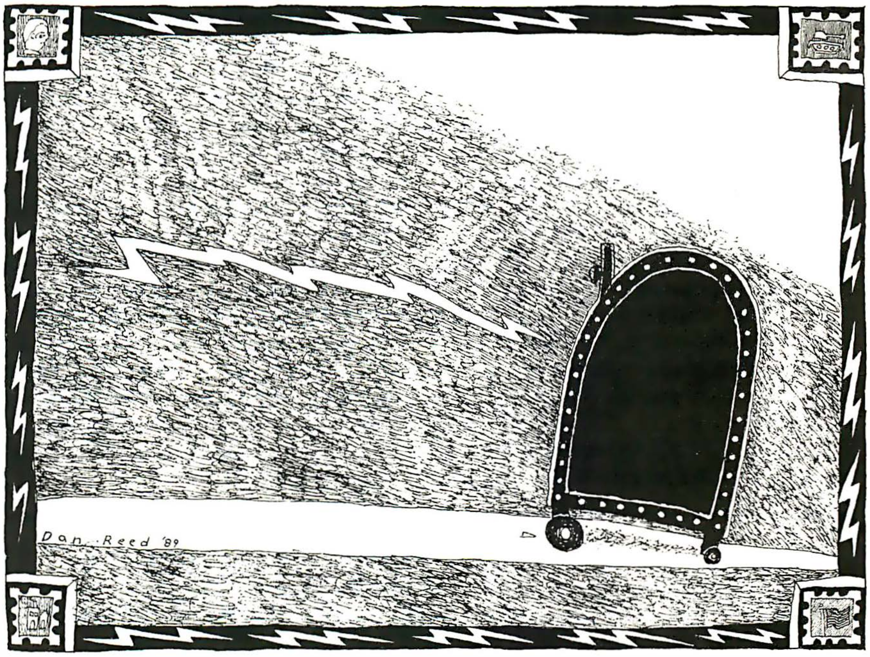
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COM1: Brock N. Meeks

E-MAIL ECONOMICS

Subtle differences in E-mail services will affect your choice of the "perfect service"



The bulldozer and the backhoe are still more important to our economy than the personal computer. The VCR and video camera are still more fun. For all the hyperbole tossed around about the information age, such prosaic industrial-age inventions as cars, cement, and diet soft drinks currently have more effect on our daily lives.

There are 87 telephones, 65 cars, and 65 TVs in the country for every 100 people. Yet the percentage of PCs hovers between 10 percent and 15 percent, depending on which expert is available for a quote that afternoon.

But don't sneeze. The type of ubiquity that it took telephones 75 years to achieve, the car 70 years, and the TV 30 years will take the computer another 10 years (or less) to achieve. And one of the best measurements of this occurrence is the overwhelming growth of the E-mail industry.

Last year close to a billion electronic messages were transmitted, according to various market research groups. That's almost five times as many messages as were transmitted in 1984.

According to Mike Cavanaugh, executive director of the Washington, DC–based Electronic Mail Association, business-related use of E-mail accounts for 90 percent of all E-mail volume. E-mail's growth in the consumer area is increasing at a slower rate than for business uses, but Cavanaugh thinks this lag is only temporary.

"People who use E-mail at the office are going to want to use it at home, too. Like the telephone in its early years, it was first used primarily for business, but then people decided they wanted to use it to call their friends," Cavanaugh said. "The trouble was, not everyone had a phone in those early days. The same applies for the E-mail industry. Not everyone has an E-mail account or even a personal computer, for that matter."

For many businesses and consumers, E-mail use has become routine. Yet as the use of E-mail ramps up, so does the confusion. The variety of E-mail services available brings to mind the state of today's telephone industry. Picking the right E-mail service for your needs is no less confusing than choosing a long-distance telephone company.

When choosing an E-mail service, you should compare features such as rates, incentive services (e.g., database access), and customer support. One of the first things you'll want to check out is rate structures—not all services are created equal.

What follows is a look at the bottom line of four popular E-mail services: CompuServe's EasyPlex, MCI Mail, Western Union's EasyLink, and BIX (see table 1).

EasyPlex

EasyPlex is CompuServe's E-mail system. CompuServe does have an alternative deluxe-type service called Executive Mail Service that offers some advantages, such as an electronic news-clipping service, but EasyPlex is more popular. And with 350,000 customers, CompuServe can accurately boast that its E-mail service has the largest number of subscribers in the world.

Charges for using EasyPlex are based on the time you spend on-line and are billed in 1-minute increments. The charges are the same as when using any of CompuServe's offerings; there is no special charge for using EasyPlex.

EasyPlex's hourly rates are in effect 24 hours a day, 365 days a week. For

continued

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1200-/2400-bps access, you'll pay $12.50 an hour; if you're still using 300-bps, it will cost you only $6 an hour. However, CompuServe also tacks on an extra 25 cents per hour to each of the above rates for access to its system via its packet-switched network.

MCI Mail

MCI Mail is unique among these four services because its rates are not time-based; you don't pay for any of the time you spend on-line. You are charged only according to the amount of messages you send. This means you can draft letters on-line or read your E-mail on-line without being charged a penny.

MCI Mail gives its users a free-access phone line in more than 50 major metropolitan cities. If you happen to live in a city that doesn't have one of these local-access phone lines, you can access the service through an 800 number or via Tymnet. There is no charge for using the 800 number, but MCI Mail charges a fee of 25 cents per minute if you use Tymnet.

MCI Mail charges you by the "MCI ounce," which equates to 7500 characters. The first ounce costs you a flat rate of 75 cents. Every additional ounce costs $1. So a message of 15,000 characters will cost you $1.75. A message consisting of 7501 characters will cost you $1.75. If you exceed the 7500-character ounce limit by even one character, you're charged for another ounce.

Recently, MCI Mail acquired the assets of RCA Mail, an E-mail service from RCA Global Communications. Users of RCA Mail have been given the opportunity to move their E-mail box to MCI or simply drop E-mail altogether.

EasyLink

Western Union's entry into E-mail was a "do or die" kind of venture. For years, the mainstay of this company's revenue was telex transmission. Beginning in 1983, Western Union funded EasyLink with $115 million of start-up funding, including $45 million for advertising.

EasyLink charges $21 per hour for 300-bps service (not so strange when you consider that Western Union telex users are used to 110-bps transfer rates). For 1200-bps access the cost is $30 per hour. These rates apply during prime time (from 7 a.m. to 6 p.m.). The rates drop some 40 percent from midnight to 7 a.m. Like MCI Mail, EasyLink is accessed via a local phone number. If your city doesn't have an EasyLink phone number, you can use a nationwide 800 number. However, if you use this 800 number, tack an additional 30 cents per minute onto your bill.

Table 1: *Charges for the various services discussed. Note that the EasyLink $25 charge is a monthly minimum usage charge. If you don't use $25 worth of the service, you're still charged $25, but there is no subscription fee per se. N/A denotes not applicable.*

Service	Sign-up fee	Hr. rate (1200 bps, prime time)	# Subscribers
BIX	$39 (one-time)	$12	27,000
EasyLink	$25 per month	$30	200,000
EasyPlex	$39.95 (one-time)	$12.50	350,000
MCI Mail	$25 per year	N/A	100,000

BIX

The Byte Information Exchange (BIX) is an electronic extension of BYTE. BIX is made up of hundreds of conferences with specialized information on computer-related or general topics in each one. A few special services have been added for variety, including two daily news-wire reports, Microbytes Daily, the McGraw-Hill Executive News Service, and a real-time chat mode called Cbix. There is an E-mail capability, too, commonly referred to by its users as "BIXmail."

BIX is accessible via Tymnet. The nonpeak (7 p.m. to 6 a.m.) hourly rate is $11. Of that $11, the actual BIX charge is $9; the Tymnet charge is $2. The peak (6 a.m. to 7 p.m.) hourly rate is $20. That breaks out to $12 per hour for BIX and $8 per hour for Tymnet charges. The rates listed in table 1 are for 1200-bps access. A special 2400-bps access rate tacks on an extra $2.50 per hour during peak times and $1.50 per hour during nonpeak times.

(For the sake of clarity, I should note that I have a professional affiliation with BIX both as a group moderator and as a contributor.)

E-Mail Benchmarks

To ferret out the bottom line for each of these systems, I've used three typical E-mail examples: a one-page memo of about 2500 characters (see table 2), a four-page letter of about 10,000 characters (see table 3), and a nine-page report of about 22,500 characters (see table 4).

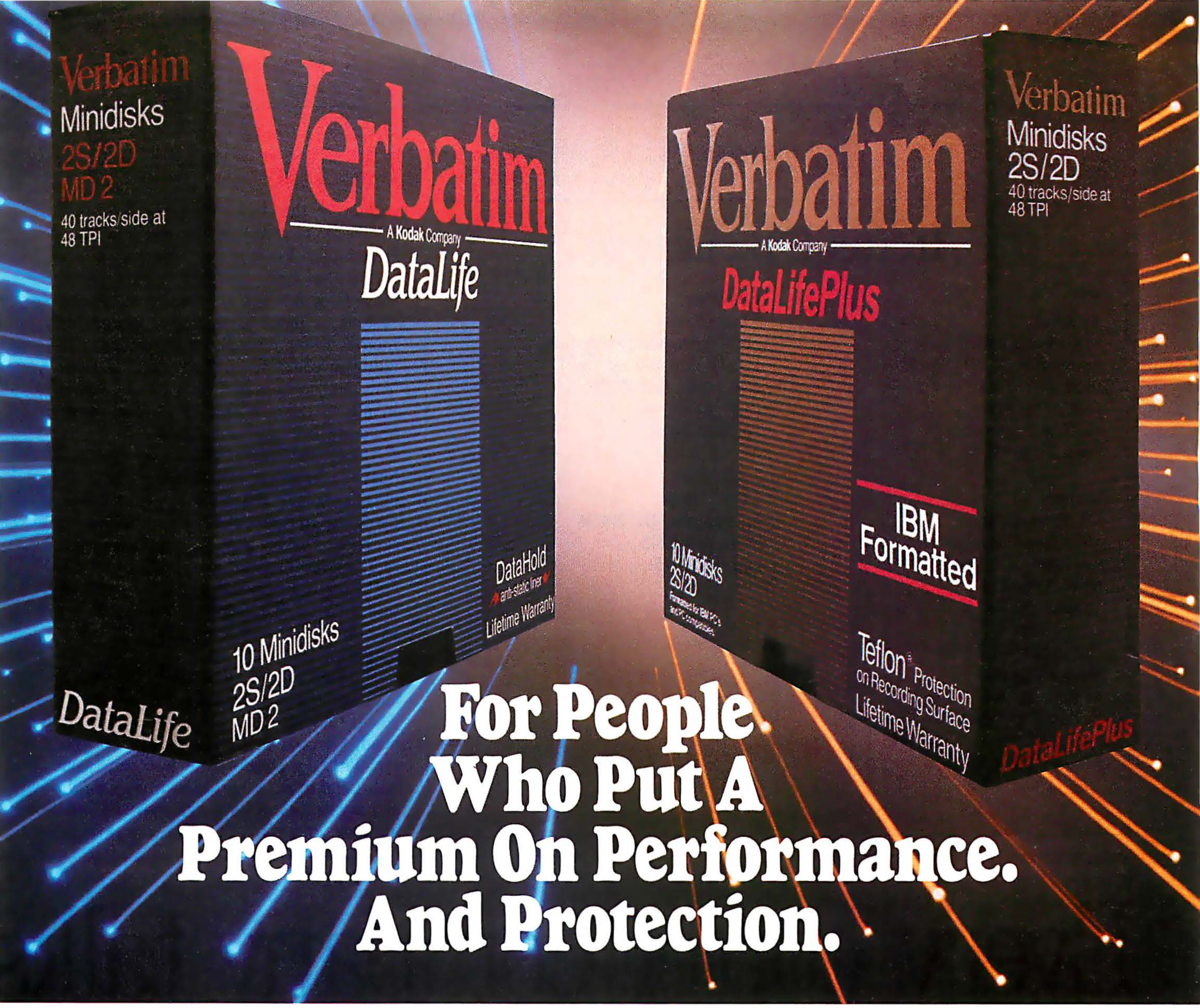
I prepared each of these examples off-line and uploaded them manually at 1200 bps during normal business hours using a straight ASCII transfer implementing XON/XOFF flow control.

At first blush, the choice for an E-mail service is easy—look at the chart, and go with the lowest overall charges, right? In all four cases, this happens to be CompuServe's EasyPlex. But such reasoning is

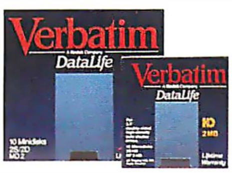
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Table 2: *A comparison of time and charges for sending messages of various lengths over the services discussed. The documents were prepared off-line and uploaded during normal business hours, at 1200 bps, using a straight ASCII transfer implementing XON/XOFF flow control. Note that MCI charges are based on document length and not on-line time. Times are in minutes:seconds.*

	1-page memo		4-page letter		9-page report	
Service	Time	Cost	Time	Cost	Time	Cost
BIX	0:29	$0.17	1:39	$0.55	3:32	$1.19
EasyLink	0:24	$0.20	1:38	$0.81	3:27	$1.72
EasyPlex	0:41	$0.14	1:55	$0.40	3:35	$0.75
MCI Mail	—	$0.75	—	$1.75	—	$2.75



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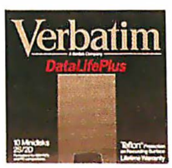


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Campbell, CA 95008
(408) 559-7434
Inquiry 1072.

EasyLink
Western Union
4230 Alpha Rd., Suite 100
Dallas, TX 75244
(800) 527-5184
Inquiry 1073.

EasyPlex
CompuServe
5000 Arlington Centre Blvd.
P.O. Box 20212
Columbus, OH 43220
(800) 848-8199
Inquiry 1074.

MCI Mail
1150 17th St.
Washington, DC 20036
(800) 444-6245
Inquiry 1075.

seductive; the choice isn't that clear-cut.

There are other factors you may want to consider. For example, there's a factor I call "on-line overhead." This is the extra time it takes to actually set up the system to input your letter, report, or memo. Using CompuServe, you have to navigate your way to the E-mail section. You can do this in two ways: by using menus or using a kind of on-line shorthand, called "go" commands.

Using the menu system on CompuServe, you might take a couple of minutes to actually reach the E-mail section; using the go commands, it takes about 30 seconds. But because CompuServe bills in 1-minute increments, you'll pay for a full minute when you use 30 seconds of on-line time. That extra minute tacks on an extra 21 cents to the actual cost of the mailing.

With the exception of MCI Mail, using each of the services mentioned here, you'll rack up some of this on-line overhead. Of course, the more familiar you are with the system, the less time you will need to set it up to input your mail. But regardless of how well you can manipulate your E-mail service, the clock is

always running. And here's where MCI Mail shines.

Using MCI Mail, you can stay on-line for as long as you wish, with no on-line overhead. This is significant when you take into account that all E-mail isn't prepared off-line, as my examples were. A simple one-page memo might take you 5 minutes to write on-line.

In addition to on-line overhead, you have to consider whether or not you want a full-service E-mail system. All these services offer extras, such as telex transmission, fax transmission, and access to special on-line information services. Though BIX does not offer telex or fax services, its on-line information service is very robust. Some of these services are priced above and beyond the on-line charges.

Then there's the question of interconnectivity, or the ability to send a message from one system to a subscriber on another system. Of the services mentioned, only MCI Mail and EasyPlex have this feature. With the other systems, you're limited to sending E-mail only to other subscribers of that service.

When choosing an E-mail service, there is an inherent advantage to subscribing to a system that has a large number of users. The rationale is simple; the more people using the system, the more likely it is that you'll be able to contact whomever you need to reach.

Using MCI Mail, you have no on-line overhead to worry about.

Reaching Nonusers

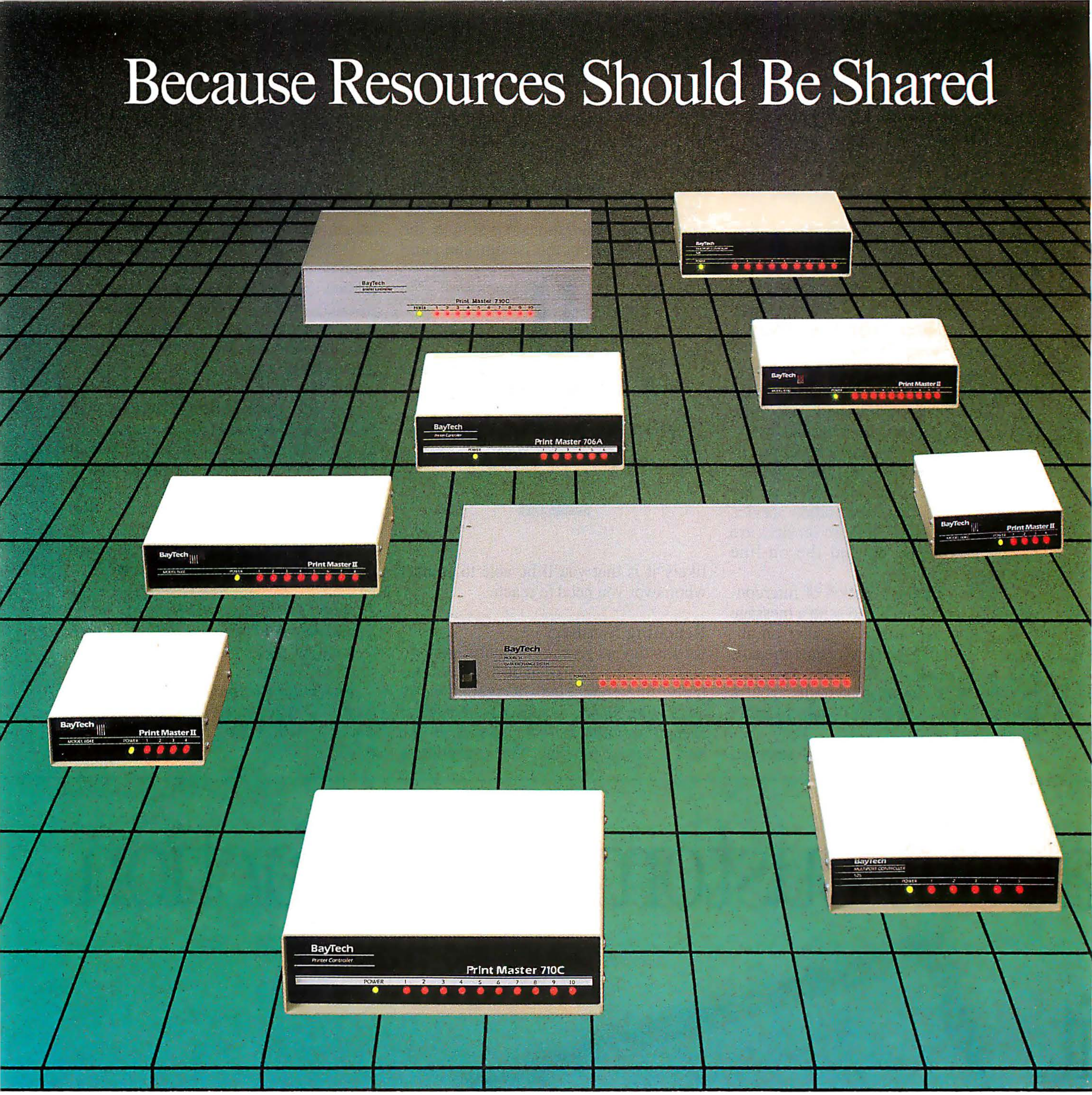
In this day of global communications—and until the E-mail industry becomes truly interconnected—it seems we're stuck with having to subscribe to several E-mail services in order to receive the best coverage possible. One exception is a service called DASnet. The folks there promise that they can "reach anyone, anywhere, with an electronic address."

DASnet operates as a kind of worldwide electronic post office for the information age. While DASnet is sometimes unreliable and has a confusing rate structure, it is the best solution to date for reaching someone via E-mail who is not a subscriber to your particular service.

While you can use statistics to help you decide which system is right for you, your best bet is to use these comparisons as a guide and then write to the E-mail companies that interest you. Ask them to send you an information package. Compare features and talk to friends who have used various E-mail services. Ultimately, you will base your decision on a combination of all these factors. ■

Brock N. Meeks is a San Francisco-based freelance writer who specializes in high technology. You can reach him on BIX as "brock."

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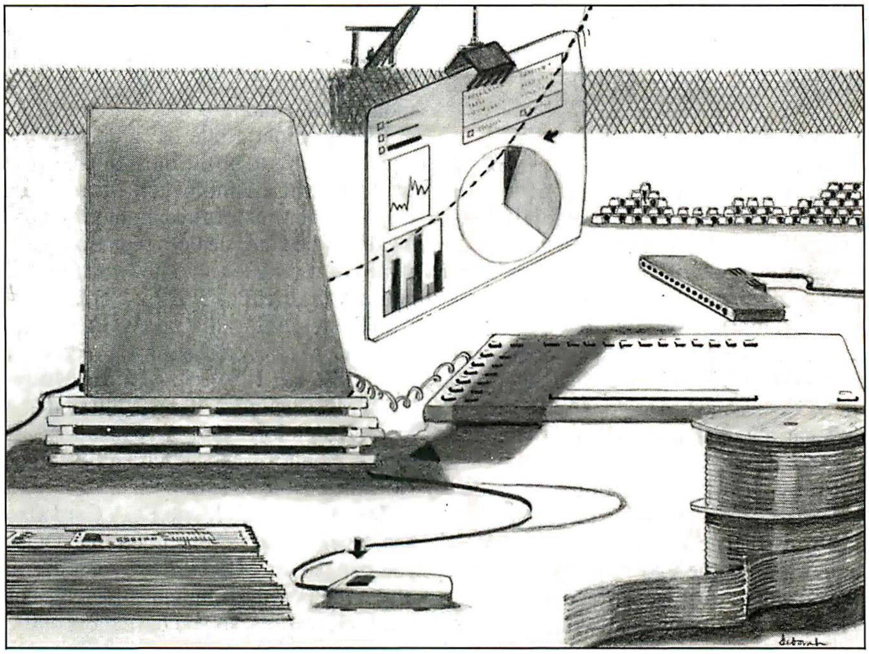
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OS/2 FOR CHEAP

Part 2 of a series showing how to put together an inexpensive OS/2 workstation



Before being interrupted by my trip to COMDEX, I was talking about building an inexpensive workstation that supports Presentation Manager (PM). So far, it consists of the following:

- a 10-MHz IBM PC AT clone with 512K bytes of RAM expandable to 1 megabyte (with a DTK motherboard and a Phoenix BIOS), a power supply, and a case
- a 3-megabyte extended-memory card (Everex RAM 3000)
- 3.5 megabytes of 256K-bit DRAMs to fill the card and the motherboard
- a Western Digital WD1003 AT-type hard/floppy disk drive controller
- a Seagate ST4096 80-megabyte hard disk drive

The total cost so far is $2990. I've gotten these things either through a mail-order house or from my local clone boutique.

Serial Ports without 8250s

Next, I'll add printer and serial ports. It makes sense to buy one of those $80 boards with one serial port and two parallel ports, which you'll find in mail-order ads. But you may want a board with two serial ports because you need a mouse *and* a modem, and this way you can support the mouse, modem, and parallel printer with just one slot. A separate mouse board wouldn't cost much, but it *would* gobble up a precious slot.

That's easy enough. But there's one important detail to buying an OS/2-ready serial port. Serial ports and internal modems are built mainly around a single chip called a universal asynchronous receiver/transmitter. The ones seen in most serial ports are an older design called the 8250. It's perfectly good, and it can be run at speeds of up to 115,200 bps, as LapLink has ably demonstrated. A new-and-improved chip, the 16450, is now available. It, too, is a UART.

Current DOS machines may have either an 8250 or a 16450—you can't tell the difference under DOS. As internal modems are also serial devices, they too have a UART. The Hayes internal modems I've seen, for instance, use the 8250. The IBM PS/2 Micro Channel architecture-compatible internal modem uses the 16450. Again, under DOS there's effectively no difference.

Under OS/2, it's another story. OS/2 will talk only to the 16450. There are many serial/parallel add-in cards, but beware: If they have an 8250, they won't even be recognized by OS/2.

If you already have a serial port, you can easily find out whether or not you have a 16450. First, remove the circuit board that provides the serial port function or the internal modem board. It's not hard. After that, remove the cover of your computer. With the power off, remove the screw that holds the serial board in place. Rock it back and forth gently, and the board will come out.

You won't be able to miss the identifying number—this is a large chip. The number may be surrounded by other characters (e.g., S8250N-B), but you'll easily see it. If you're worried about doing this, find someone who's been under the hood of a computer before.

If you're buying a PM-ready workstation, be sure to ask the vendor whether or not the serial ports use an 8250 or a 16450. If you can't get an answer, don't buy from that vendor.

Suppose you already have an 8250-

continued

based serial port—must it go in the trash? BYTE's hardware expert, Brett Glass, tells me that he has been able to make OS/2 happy by simply replacing the 8250 with a 16450. Many parallel/serial boards mount the 8250 with a socket, so you can replace the 8250 with a 16450 without any soldering. You can probably find a place that will sell you a 16450 in the back of this issue. Jameco Electronics is a longtime BYTE advertiser that handles chips. On the other hand, if your UART is *not* socketed and you're not comfortable with a soldering iron, perhaps it's best to buy a new board.

There are boards around that offer two serial ports and a parallel port for $80. The total now reaches $3070.

EGA or VGA?

The PM doesn't support CGA—well, it does, but not credibly—or Hercules graphics, so the workstation will have either EGA or VGA. There's a number of reasons to go with VGA rather than EGA, and perhaps I'll tackle them in a future column. For now, it's enough to say that the cost difference between EGA and VGA—$150 for EGA versus $400 for VGA—is enough to go with EGA.

What about the so-called EEGA, the "extended" EGA card with the snazzy 800- by 560-pixel resolution mode? There's no real point in buying one of these, as the nonstandard modes aren't supported by the PM anyway. But this may change. Just as Paradise, Genoa, Video Seven, and the rest have written special Windows drivers to show off their cards, perhaps we'll soon see similar drivers for the PM.

My associate, Rob Oreglia, has railed for years now against color monitors. "They're of no use to you," he argues. "Say you get a pretty color screen—how do you get a hard copy?" I can't argue with him.

The bigger problem is that color monitors are expensive. A monochrome monitor is cheap—$70 tops via mail order, $95 for the "paper-white" screens. EGA monitors all seem to start at $350 and go up from there. Additionally, monochrome monitors produce nice, sharp text. So, to really make this cheap, we'll shoot for an EGA card that can support a basic monochrome TTL monitor in EGA resolution by displaying different shades. Simple, you may say—any auto-switching display card will handle that.

That's just the problem, you see. Autoswitching *kills* OS/2.

I've tried a number of video cards with OS/2—ATI's EGA Wonder, Quadram's QuadEGA+, and Paradise's EGA cards

> *The bigger problem is that color monitors are expensive —$350 and up.*

—and every one of them causes OS/2 to lock up when trying to boot if the card has auto-switching enabled. What's needed is a video card that boots up in EGA mode and doesn't squawk about emulating a full 256K-byte EGA on a monochrome monitor.

I've tried out a pile of cards, and the one that seems to be the most trouble-free is the Paradise AutoSwitch Mono EGA Card. Be very careful when buying this, however, because dealers seem to be unaware of its existence. They want to sell you a Paradise Basic EGA Card, or an AutoSwitch EGA 480, or a VGA Professional Card. . . . Make sure you're getting the right card by specifying Model 02-17. It lists for $279, but I found it at a local dealer for $199. A Samsung TTL amber monitor was $80 with a tilt stand. Now the cost is up to $3349.

The AutoSwitch Mono EGA Card also has other virtues. When running DOS, you can use its MEGA.EXE software to direct the board to emulate a Hercules or CGA video card, so you have most of the bases covered. I don't know of anyone at the moment that offers a similar card for VGA, but someone probably will in time.

Rodent

Some of us think mice should be in laboratories testing vaccines, but the PM needs a mouse. What's a good one? I use the Microsoft Serial Mouse. Yes, you *can* run PM without a mouse, but you have to have a head for the trivial, shall we say? You want to make drive A the default drive? Just press Control-A. Want to move from one window to another? Alt-Tab.

My advice against using the keyboard to control Windows or PM is not based on a small amount of experience; at my desk, I use a mouse. When doing PM classes, however, I often find myself having to use the keyboard, as computer rental companies are often unequal to the task of supplying a working mouse.

OS/2 claims to support several mice, and I guess it doesn't matter which one you use. I like a serial mouse for reasons I cited earlier—you save a slot. The Microsoft Serial Mouse is about $95.

Floppy Disks Required

OS/2, being large, can't be booted from a 360K- or 720K-byte floppy disk. Since it arrives in the 1.2- or 1.44-megabyte flavor, you need a 1.2- or 1.44-megabyte drive A. OS/2 is so large that you don't really boot it upon installation—you just boot a minimum program that is smart enough to load the five disks. Then it tells you to reboot, and at that point you're in. That's part of the reason why the FORMAT /S option does not work under OS/2 1.1.

The 1.44-megabyte floppy disk seems to be the disk of choice for IBM—it was easy to get the PM on 1.44-megabyte disks weeks before it was available on 1.2-megabyte disks—so be sure that whatever machine you buy will support a 1.44-megabyte disk down the line.

Now the tally is up to $3444, and that's final. Of course, you need to buy software, but that's for another day. Summarizing, the workstation ended up including the following:

- a 10-MHz IBM PC AT clone with 512K bytes of RAM expandable to 1 megabyte (with a DTK motherboard and a Phoenix BIOS), a power supply, and a case
- a 3-megabyte extended-memory card (Everex RAM 3000)
- 3.5 megabytes of 256K-bit DRAMs to fill the card and the motherboard
- a Western Digital WD1003 AT-type hard/floppy disk drive controller
- a Seagate ST4096 80-megabyte hard disk drive
- a Paradise AutoSwitch Mono EGA Card
- a Samsung amber TTL monitor
- an I/O card with two serial ports and one parallel port (serial ports with the 16450)
- a Microsoft Serial Mouse

Once the workstation is set up, the *real* fun begins when you start arranging files. When OS/2 installs itself on your disk, it installs itself *all over* your disk. I'll talk about the files that OS/2 drops on your machine next time. ■

Mark Minasi is a managing partner at Moulton, Minasi & Company, a Columbia, Maryland, firm specializing in technical seminars. He can be reached on BIX as "mjminasi."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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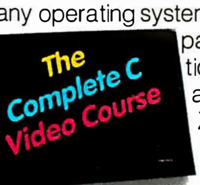
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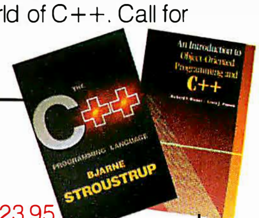
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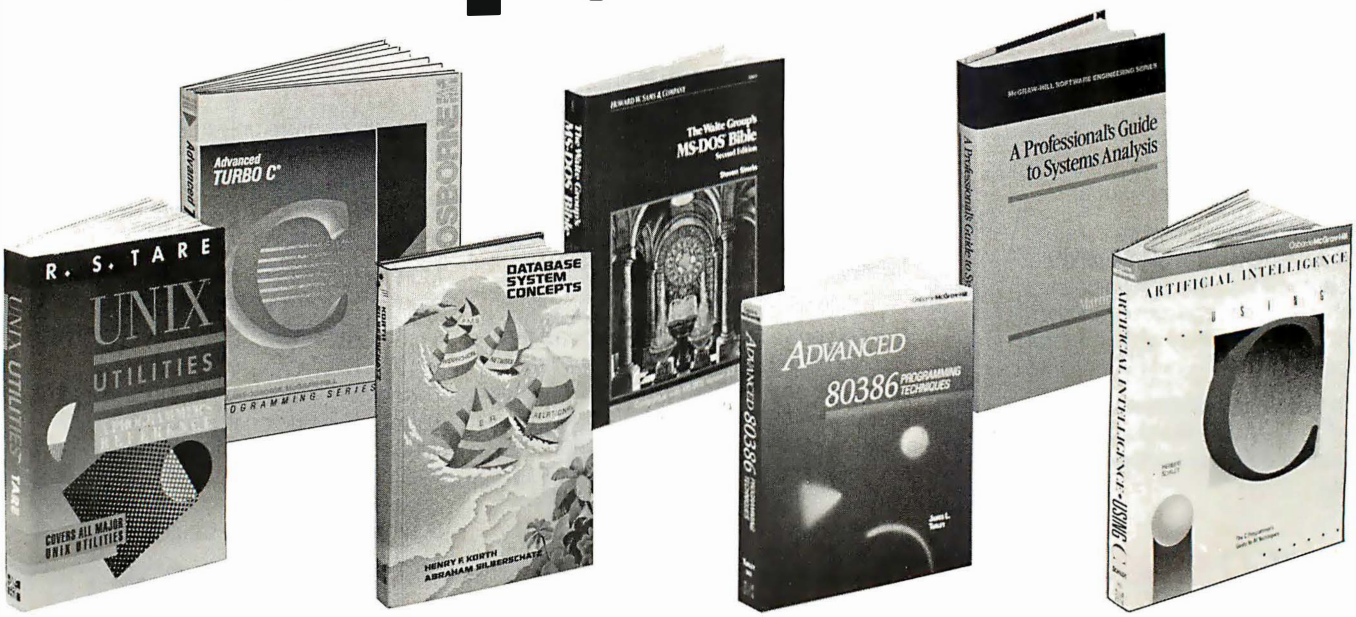
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Curing the Brownout Blues

Ka-thunk. The lights dim. Your heart stops. For a moment, you are frozen. Time seems to stand still. Then you hear the familiar sound of your computer booting. To you, it sounds remarkably like a toilet flushing your precious data down the drain. If only you would learn to save your work more often. If only . . .

All of us who use computers live on the edge. Yes, you have heard all the adages about saving your work and backing up everything, but do you really do it as often as you should? At some point, you enter the danger zone, where one good lull in the power line could cost you greatly in terms of lost data. Not even an uninterruptible power system (UPS) can promise absolute protection, but it can offer some peace of mind to those who fear the dreaded power brownout.

Consider the following disquieting information. In 1972, 1975, and 1983, IBM published studies on utility power across the U.S. (the 1983 survey also included Japan and Europe), recording incidents—out-of-specification fluctuations above and below line voltage. Though frequency of fluctuations depends heavily on your location, on average, the frequency of such incidents rose from 12 percent to 27.3 percent, and the number of outages increased from 5 percent to 15 percent.

In its *Gold Book*, the IEEE recommends that computer equipment be designed to operate within a steady-state window 6 percent above and 13 percent below normal line voltage. Most computer equipment available today complies. But the largest group of incidents recorded by the IBM study covered sags of 20 percent; the second largest group (and growing) included sags of 30 percent (it tied with total blackouts). More than half of all incidents lasted less than 6 seconds. If your work is intimately tied to your microcomputer, you would be wise to purchase a UPS. (For a primer on UPS technology, see the text box "What Is a UPS?" on page 168.)

The BYTE Lab looked at 12 UPSes (see table 1). Each unit is rated at under 1500 volt-amperes (VA)—designed primarily to support microcomputers or networks. We were looking for units to provide reliable backup power; we did not test for overvoltage protection. While surge and spike suppression are important to line quality and are often offered as enhancements, they don't fall within the traditional domain of the UPS.

UPS Testing

The words behind the UPS acronym suggest that such a product provides power that is, within reasonable limits, uninterruptible. Testing a UPS means determining just how invulnerable to interruption it really is—feeding it less-than-ideal power and looking at how much of the disturbance the unit passes on to your computer.

To provide power disturbances, we used a Variac rated for 120-/240-volt inputs, a 9-A load, and output voltages ranging from 0 V to 280 V. A Variac is a variable autotransformer, a device that let us convert fixed line voltages (from the wall socket) to any 60-Hz voltage within the given output range. The Variac let us do simple but realistic and repeatable simulations of low line voltages.

We monitored UPS inputs and outputs using two line monitors to measure root-mean-square voltage and an oscilloscope to capture actual voltage waveforms. The first line monitor is a BMI GS-3, a low-load instrument that gives a constant reading of RMS voltage when connected to a power outlet. The unit gives reliable readings for sine waves only, so we used it to test only inputs.

To monitor UPS outputs, we used a BMI 2400 Power Scope, a similar but more sophisticated device that gives true RMS readings, even for nonsinusoidal waves. For waveform acquisition, peak voltage measurements, and timings, we used a Hewlett-Packard Model 16530 digitizing oscilloscope.

A line-switching device developed by Emerson rounded out our test equipment. The Emerson box uses a solid-state switch to toggle its output between direct connection to line voltages and connection to line voltages through the Variac. The output is normally connected directly to the power line. The Variac input acts as a variable voltage source or, when set to other than line voltage, as a disturbance input.

When the switching device is activated, the solid-state switch connects the output to the Variac (the disturbance input) for a short time, then switches back to normal line voltage, without disturbing the phase. The test instrument also generates a trigger signal so that we could monitor each disturbance with the oscilloscope. Timing controls let us choose both the duration (from 0.2 millisecond to 683 ms) and the start time (as a position on the sine wave) of the disturbance; adjusting the Variac let us select its magnitude. With the Emerson unit, we were able to replicate most common line faults in both size and duration.

Table 2 shows our results. It includes a single figure for cutoff voltage and restart voltage, and three figures for output voltage. The cutoff voltage represents the input level at which the UPS kicks in—where it generates an input fault alarm and, if necessary, switches to backup power. We measured the cutoff voltage by connecting the UPS being tested directly to the Variac and lowering the voltage until the test unit responded. After recording this cutoff voltage reading, we turned up the Variac until the test UPS switched back on; the turn-on level is the restart voltage.

As a caveat, these two figures can be affected by the impedance of the Variac and the nonlinear current draw of the units being tested. Each UPS was loaded with an IBM PS/2 Model 80 and a monitor (168 VA) connected to its output.

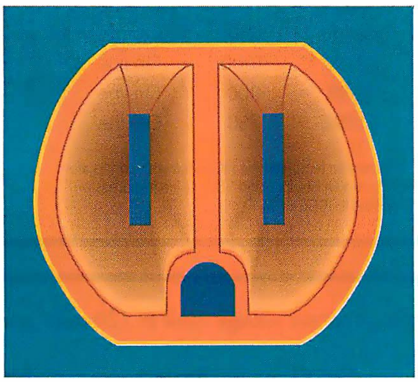
The three output voltage numbers rep-

Twelve UPSes that can help you sleep better at night

Steve Apiki, Stanford Diehl, and Rick Grehan

resent the normal, backup, and minimum steady-state voltages present at the UPS output. To perform the normal output test, we plugged the UPS into the line socket, loaded it with the Model 80, and determined RMS output. We also used the oscilloscope to get a picture of the normal output waveform.

To find the backup voltage, we disconnected the UPS from the line and again measured the output. Minimum output voltage is the RMS reading for the unit just before switching to backup, if the unit is a standby power system (SPS), or the smallest voltage reached while the input is reduced to zero. To read this, we wired the test UPS to the Variac and turned down the input voltage, recording the minimum output value.



We used the oscilloscope to measure the effect of four undervoltage line disturbances that were generated by the Emerson box. The voltage levels were set at minus 30 percent from nominal line; we used ⅛-, ¼-, ½-, and one-cycle durations. Each disturbance began at a positive slope zero crossing. We made qualitative observations and measured peak voltages from the scope trace. Again, we loaded the test units with a PS/2 Model 80.

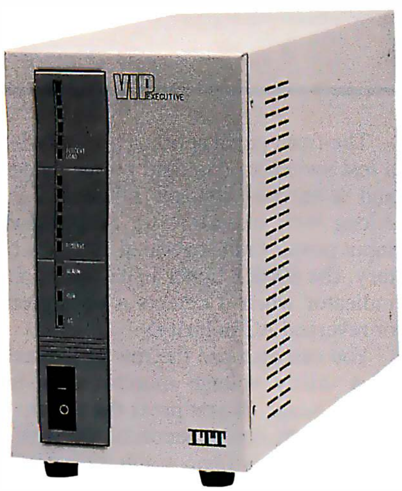
To determine transfer times and their sensitivity to different loads, we sent one-cycle near-blackout voltages (minus 75 percent) to each of the six SPSes. Using the storage oscilloscope, we captured the resulting waveforms and measured the transfer times (see photo 1). We performed the test twice, once with a small load (the Model 80) on the UPS and once with a moderate load (420 VA).

We supplemented the disturbance tests with a measurement of holdup time (how long a UPS/SPS can provide usable power when disconnected from the wall). Because the holdup time's load response can be nonlinear, we used loads of three sizes. The small and moderate loads corresponded to those used in the transfer-time test.

We also used a large (672 VA) load to put a realistic

continued







Three of the best: *ITT PowerSystems' VIP 800 (left), Sola Electric's Mini UPS/2 (middle), and the Emerson PC/ET (right) represent products designed for medium-, large-, and small-load requirements.*

Table 1: *A summary of critical UPS features.*

	Price	Output power (VA)	Type	Waveform				
				Type	THD	RMS (V)	Reg.	Peak (V)
American Power Conversion 800RT	$1099	800	Standby	Sine	2%	120	2%	170
Computer Accessories Power Saver U1200	$1295.95	1200	Standby	Modified square	N/A	120	5%	165
Computer Power Computersave Mark II	$2219	750	Standby	Sine	5%	120	2%	170
DRS Power Products UPS	$654	1000	Standby	Modified square	N/A	115	N/A	145
Emerson PC/ET	$995	360	On-line	Sine	5%	120	5%	170
Exide Electronics Micro UPS 800	$1199	800	Standby	Sine	2%	120	5%	170
General Power EPD Unistar U1000	$2699	1000	On-line	Sine	3%	117	2%	N/A
ITT PowerSystems VIP 800	$1699	800	On-line	Sine	5%	120	3%	170
Kalglo Electronics Line-Saver LS-750	$995	750	Standby	Modified square	N/A	120	4%	160
Sola Electric Mini UPS/2	$3712	1000	On-line	Sine	5%	120	3%	170
Unison UniPower DP 800	$995	800	On-line	Stepped square	N/A	115	5%	170
Viteq Benchmark Model 386/LAN	$1895	750	On-line	Sine	5%	120	2%	170

1 Includes detection and switching time.
2 Specified recharge time may vary from 85 percent to 100 percent full charge.
3 Protection features key: NC = network connection, NF = noise filtering, and SS = spike suppression (tested to IEEE-587).
4 Specified as zero, some distortion for 8 ms.
5 Optional feature.
6 Number in parentheses indicates total outputs, including bypassed (not backed-up) outlets.

Table 2: *The test results. The ideal UPS has an output voltage close to 120 volts at all times, and zero (or N/A) transfer times.*

	Cutoff voltage (RMS)	Restart voltage (RMS)	Steady state output voltage (RMS)			Measured transfer time (ms)	
			Normal	Backup	Min.	Small load	Moderate load
American Power Conversion 800RT	101	105	117.5	122.0	101.5	6.6	6.0
Computer Accessories Power Saver U1200	99	100	118.9	120.3	100.2	4.8	4.6
Computer Power Computersave Mark II	86	91	120.2	122.4	118.5	0[1]	0[1]
DRS Power Products UPS	101	108	118.3	133.5	101.7	11.8	13.0
Emerson PC/ET	84	95	117.9	117.9	117.9	N/A	N/A
Exide Electronics Micro UPS 800	101	106	117.8	121.1	101.6	8.2	8.2
General Power EPD Unistar U1000	79	91	118.6	118.6	118.6	N/A	N/A
ITT PowerSystems VIP 800	96[2]	96[2]	118.3	118.3	118.3	N/A	N/A
Kalglo Electronics Line-Saver LS-750	102[3]	105	117.9	131.5	103.5	17.4	17.4
Sola Electric Mini UPS/2	94	103	119.3	119.5	119.5	N/A	N/A
Unison UniPower DP 800	96	104	122.6	121.4	121.3	N/A	N/A
Viteq Benchmark Model 386/LAN	82	92	116.7	117.2	116.7	N/A	N/A

1 No abrupt switch, but voltage degradation (15 percent to 20 percent) for 12 ms to 16 ms.
2 No clearly defined transfer point.
3 Default value; transfer levels are adjustable.

stress on the larger units. As was true with the moderate load, the large load was an even mixture of computers and monitors. We did not test any of the 750-VA units with the large load because the difference between rating and actual load left a very slim margin of error, less than some manufacturers recommend. We charged each UPS for 24 hours between tests, loaded them, and then disconnected them from the line.

Powerful Impressions

Our test results were the primary source of information used in evaluating these UPSes. Other sources include features claimed by the manufacturer that may or may not be testable (e.g., long battery life or warranty) and subjective impressions. A summary of each UPS's performance follows.

American Power Conversion 800RT: The 800RT offers some valuable features at a reasonable cost of $1099. Like all SPSes, this 800-VA unit cannot provide absolute uninterrupted power during an AC outage, but its transfer time is acceptable, and it generates a pure sine wave during backup operation.

The front panel sports a power switch, a test switch to simulate power outages, and a vertical row of indicator lights. Along with indicators for output ready, input power fault, overload, and low battery, the 800RT lights a site-wiring fault indicator when it detects a poor ground or reversed AC polarity.

You can also use the row of indicators as a utility voltage monitor or a load power gauge. If you press the alarm disable switch for 4 seconds, the row of lights becomes a bar-graph indicator displaying the input voltage level. If you press the test switch for 4 seconds, the

Transfer time[1] (ms)	Full-load holdup time (minutes)	Battery-recharge time[2] (hours)	Outlets	Other protection features[3]	Warranty (years)	Size (inches)	Weight (lbs.)
4	5	10	6	NC, SS, NF	1	11.5 x 7.7 x 14.5	52
3	10	8	4	NC, SS, NF	1	16.5 x 6.4 x 18	74
0[4]	15	4	4	NC[5], SS, NF	1	12.5 x 12.5 x 21	125
6	10	8	4	NC, NF	2	9 x 11 x 18	60
N/A	7	35 minutes	3 (6)[6]	SS, NF	1	2.3 x 15 x 14.8	23
4	6	10	6	NC, SS, NF	2	11.5 x 7.7 x 14.5	52
N/A	10	N/A	3	NF	1	18 x 7.9 x 19.5	93
N/A	10	8	3 (5)[6]	NC, SS, NF	1	10 x 6 x 16	39
4	11	12	2	NC[5], SS, NF	2	5 x 8.5 x 13.2	38
N/A	8	2	4	NC, SS, NF	1	20 x 11 x 22	145
N/A	6	4	4 (8)[6]	NC, SS, NF	1	2.9 x 18 x 16.5	34
N/A	10	2	4	NC, SS, NF	1	11.5 x 8 x 19.5	65

Measured holdup time (hrs:min:sec)		
Small load	Moderate load	Large load
0:43:37	0:15:47	0:07:21
2:05:55	0:44:15	0:23:34
1:09:55	0:35:26	N/A
1:08:10	0:29:51	0:14:43
0:12:25	N/A	N/A
0:40:05	0:15:41	0:07:28
2:22:30	0:41:38	0:20:25
0:56:22	0:22:51	0:11:35
0:30:04	0:07:59	N/A
1:08:26	0:36:34	0:21:07
0:33:45	0:10:19	0:05:13
0:44:22	0:17:33	N/A

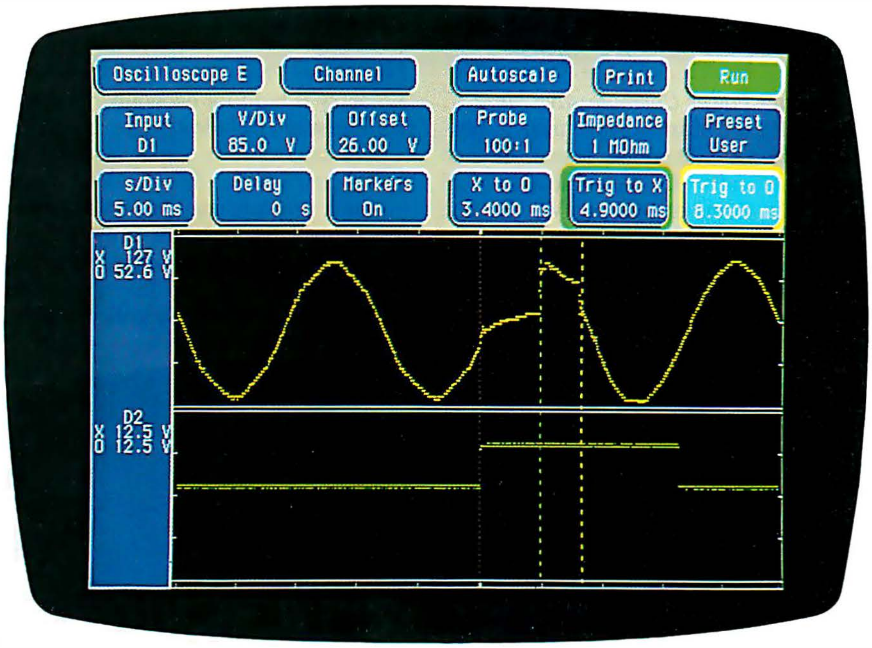


Photo 1: *Transfer-time measurement for standby power systems. The measurement is from disturbance to full recovery. (Shown here is the American Power Conversion 800RT waveform.)*

bar-graph indicator displays the protected load at thresholds of 130, 250, 360, 470, and 600 VA.

The 800RT provided 43 minutes and 37 seconds of battery backup for a small load, and 7 minutes and 21 seconds of backup for a large load. A continuous alarm sounds when the unit nears shutdown. The battery kicks in at 101 V, responding smoothly after a 6-ms transfer time. A network connection at the rear of the unit alerts any computer connected when shutdown is imminent, allowing supported software to respond by gracefully closing files. (This connector is adaptable to many network systems, including Novell NetWare, Banyan or Tallgrass running VINES, and others.)

Computer Accessories Power Saver U1200: Though physical design is not normally an important criterion when selecting a UPS, this 1200-VA model certainly deserves credit for ease of installation. It has the heft usually associated with such a high-capacity unit, but solid carrying handles and a good rectangular layout make it easy to place and move. A lighted front-panel on/off switch is the only control necessary—and the only one provided, though there is an audible power-fault alarm. The unit has a self-test that it performs at each start-up.

The battery is of average capacity, rated at 10 minutes full load. Its high VA rating does, of course, increase holdup

continued

time for smaller loads; our Model 80 and monitor were operational for over 2 hours with input power to the UPS disconnected.

At $1295.95, the U1200 compares favorably to most of the other UPSes that we reviewed in the critical dollars-per-VA category. In terms of pure output quality, however, two factors weigh against this system: SPS design and nonsinusoidal output (see photo 2).

While the waveform type and transfer time are less than ideal, these problems are not as serious as they could be. The waveform is very close to sinusoidal (peak 165 and RMS 120), and the transfer time is relatively short. Transfers are also made in phase. The unit needs no hysteresis in the cutoff level, since the inverter remains on for at least 5 seconds regardless of the duration of the transient. Though the inverter mechanism is of a cheaper design than those of some of the more costly UPSes we reviewed, the better-than-average implementation stems some of the problems associated with the square wave/SPS scheme.

Computer Power Computersave Mark II: At $2219, the Mark II is the most expensive 750-VA system we tested. It also ranks second to the Sola Electric Mini UPS/2 in terms of cost per VA. But the unit offers features in proportion to price: Sine-wave output, outstanding battery capacity, and an output storage transformer contribute to the Mark II's good all-around performance.

This UPS has an odd appearance, with a large housing for the inverter and switching electronics connected via a back-panel cable to an external battery box. Its external battery design lets you add more batteries or replace worn-out modules without exposure to the potentially dangerous voltages inside the system. A power switch, an audible alarm, and front-panel LEDs provide control.

Though the Mark II is an SPS, the output storage transformer makes the effects of switching to the inverter almost unnoticeable and puts it in a slightly different category. The transformer is connected between the AC source (line or inverter) and the UPS output. While line-to-inverter switching takes place, the transformer holds up the output long enough to ensure a smooth transition. Transfer time is not easily measured from the scope trace, as the effect of switching is to degrade the output voltage about 15 percent to 20 percent for close to one cycle.

DRS Power Products UPS: DRS's 1000-VA entry is built for economy. Cost-saving measures include standby operation, a pure square-wave output, and limited spike protection. While the backup power it provides may be less than perfect, this UPS sells for only $654—a quarter the price of the next most expensive 1000-VA unit, and the only system in the group at less than a dollar per VA.

The standby output is a square wave, which our measurements show has an RMS value around 133 V. Frequency on the unit we tested was near 66 Hz. DRS told us that our Model 80 test load was too small for this high-capacity unit and said that frequency variances are usually limited to between 58 Hz and 62 Hz.

Transfer time was relatively poor, rated at 6 ms and measured at 11.8 ms. The UPS also failed to switch on short-term (one-cycle) brownouts. Holdup time was poor compared with units of a similar power rating, but the system outperforms more expensive units with lower ratings.

One helpful feature that this no-frills device does provide is LED bar graphs to monitor load and battery charge levels. The bar graphs give a better indication of emergency power available than the usual audible alarm only.

Emerson PC/ET: The Emerson PC/ET provides true on-line protection for only $995. While this compact unit supplies only 360-VA output from its three UPS-protected outlets, conditioned output is available from two additional sockets. The PC/ET generates a true sine wave and maintains remarkably consistent output regardless of input conditions.

Front-panel indicators monitor load level in 20 percent increments, battery charge, presence of AC power, and overload conditions. In addition to a master power button, each rear-panel outlet is controlled by its own front-panel switch. The unit furnishes noise filtering and spike suppression, but it has no network connection. Battery power lasted 12 minutes and 25 seconds while connected to a small load. The low VA rating prevented us from testing the other two loads.

This on-line UPS looks tempting when you see the low price tag, and if your power requirements are modest, you should give it a look. Upon closer inspection, however, the PC/ET is not as cheap as it seems. Only the Mini UPS/2 and the Computersave Mark II are more expensive when considering cost per VA. It does offer true uninterruptible power for less than $1000, a viable alternative to the inexpensive standby units.

Exide Electronics Micro UPS 800: This $1199 unit provides 800-VA standby power from six rear sockets. It supplies spike suppression, noise filtering, true sine-wave output, and a network interface.

Front-panel indicators are identical to those on the 800RT, including the diag-

continued

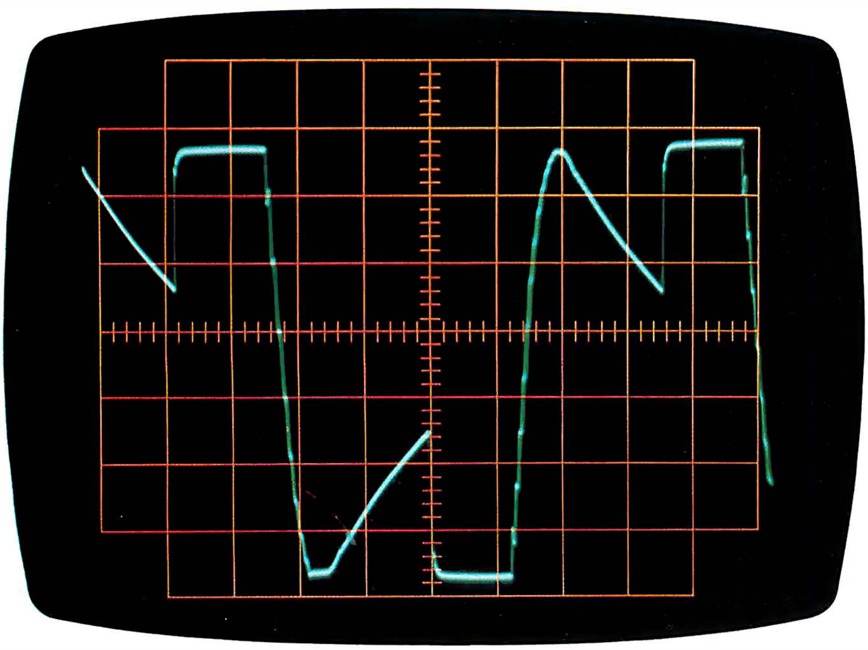


Photo 2: *The modified square-wave output of the Computer Accessories Power Saver U1200.*

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What Is a UPS?

Mark Waller

The acronym UPS stands for "uninterruptible power system." Notice that this is not a power *supply*. It is an external *system* for providing continuous power when the utility supply fails. A power supply is a subassembly inside the microcomputer that converts the utility's AC power to DC, which is what the logic circuits of the microcomputer need for working energy.

To make matters a little more complicated, not every UPS is truly uninterruptible. These units are more correctly called standby power systems (SPSes). Also, some designs are uninterruptible and yet standby at the same time.

The reason for this blurring of terms is related to the microcomputers themselves. A microcomputer's power supply has what is called *ride-through*: the amount of time that the power supply can deliver stored energy to the logic circuits with no electricity being fed to the supply. This energy storage is directly related to the size and quality of the power supply components, particularly the filter capacitors. The ride-through of microcomputers is from 20 milliseconds to 40 ms—a long time in the world of electronics. Some designs have an even greater tolerance for very short-term dropouts.

The SPS

This long ride-through allowed the SPS to become the most popular of these devices for the microcomputer market. Figure A shows the block diagram of an SPS. The incoming utility power is fed directly into the microcomputer under normal conditions. When utility power fails, the transfer switch senses this happening and turns on the inverter, which converts battery power (DC) into an AC source that keeps the microcomputer running.

When utility power returns, the switch returns the microcomputer to utility power. It is easy to see why this is a standby technology. The inverter is literally "standing by" waiting to be turned on.

The UPS

So what is a true UPS? Figure B shows the block diagram of a true on-line UPS. The incoming utility power is converted from AC to DC by a *rectifier/charger*. As the name implies, this unit performs two functions: It changes the power to DC (the rectifier) and charges the battery. The battery floats on a DC bus (i.e., the conductor that connects the rectifier/charger and the inverter). If the battery needs charging, it draws power from the bus. If, on the other hand, the bus voltage level falls below the battery float voltage, the battery delivers energy to the bus.

The energy conducted through the DC bus provides power to the inverter (which, in turn, provides power to the microcomputer). In other words, the system is on-line all the time. Thus, a full-time AC-to-DC-to-AC conversion takes place. The advantage of this design over the standby design is that no switching takes place if utility power fails. Since the inverter is always providing power to the load (the microcomputer), the microcomputer never sees an interruption of power.

This feature comes at a price, however. Since the duty cycle of the components is 100 percent, they must be bigger with higher ratings. This means that the on-line design can cost twice as much or more than a standby unit of the same rating.

One More Design

A *ferroresonant transformer*, designed many years ago, has the unique ability to store energy for a few tens of milliseconds. Figure C shows how this device can enhance the performance of the simple SPS. Notice that all the blocks are the same, but that the transformer has been added at the output. With this design, the time that it takes to switch on the inverter is covered with the ride-through capability of the transformer. Therefore, the microcomputer is unaware that any switching has taken place.

A ferroresonant transformer adds cost to the basic SPS. It also adds some power conditioning. Expect to see prices for these units somewhere near but not quite as expensive as the on-line variety.

Features

What features should you look for when purchasing an SPS? The first concern is switching time. The unit must be able to switch its inverter on and gracefully pick up the electrical load before the microcomputer's internal ride-through expires. Typical switching times are from 4 ms to 10 ms, including the time it takes to sense an outage and complete the switching process. The SPS does this by setting an internal transfer point. When the utility voltage (120 volts) falls below a predetermined level, say 100 V, the SPS begins the switching process. This ensures that by the time voltage reaches a dangerously low level, the microcomputer will already be on-battery.

A selectable transfer point is an important feature. The switching power supply inside most microcomputers has a working voltage window that is enormous, from about 80 V to nearly 140 V, implying that voltage regulation is not normally necessary. It also implies that if your site experiences chronic brownouts or low-voltage conditions, you may want to buy a unit that lets you select a low transfer point (possibly in the 90-V range) so that you are not unnecessarily transferring to a battery.

The next feature to look for is an extension of the transfer point, referred to as *hysteresis*. This means that the retransfer point (the voltage at which the SPS goes off-battery when utility power returns) should be above the transfer voltage so that "chattering" on- and off-battery does not occur if the utility voltage hovers near the transfer point. A typical hysteresis window might have a low of 102 V and a high of 107 V.

When an SPS retransfers, you want the waveform output of the inverter to slew to match the phase of the incoming utility power. This is called *synchronizing* or *phase matching*. When the two waveforms are in phase, no gap will occur when retransfer takes place. Can this gap be long enough to be interpreted as an outage by the microcomputer? Engineers might disagree about this probability, but designing this feature into the product shows professional concern for the quality of the device.

Low-battery shutoff is another feature to look for. When batteries power a load during a power outage, their stored energy is slowly depleted. At some point, the depletion is so dramatic that the voltage level of each cell in the bat-

tery begins to drop. At a level called the *end voltage*, further discharge will permanently damage the cell. To preserve the life of the battery, most quality SPSes shut off the inverter before this happens. Without this feature, your SPS may survive only a few long-term outages. Ideally, of course, you will shut down the microcomputer and the SPS before this happens.

Waves

Most of us are familiar with the sine waveform of utility power. However, most SPSes do not put out a sine wave; it is considerably cheaper to put out a square wave, a rectangular wave, or some quadrilateral in between.

The inverter, you see, is basically a very fast switch. To produce a sine wave, a switching scheme must be devised that builds some kind of approximation to a sinusoid using a series of pulses. This is then filtered to produce a smooth product that looks like normal utility power.

The switching process of the inverter creates a lot of high-frequency electrical noise. To produce a sine wave, most of this noise is eliminated during the filtering process. With a square wave, on the other hand, no such filtering is necessary to produce power that the microcomputer will run on. However, the chance that inverter noise will be present at the SPS's output is far greater. Add to that the fact that a square wave is not a fundamental of 60 Hz (the frequency of power), as is a sine wave. The "shoulders" of the waveform contain odd harmonics of the fundamental 60-Hz signal.

This means that the manufacturer must take care to eliminate noise from the nonsine wave of an inverter. (If this is done, there is no real reason to shy away from nonsine-wave products.) As a result, sine-wave units typically put out less interference and cost more money.

Power Conditioning

Damaging impulses or spikes come in two different varieties: normal mode and common mode. Normal-mode events can be measured between the black building wire (hot) and the white building wire (neutral). Common-mode events are measured from the white building wire to ground (see my two-part "PC Power" in the October and November 1988 BYTE). A normal-

continued

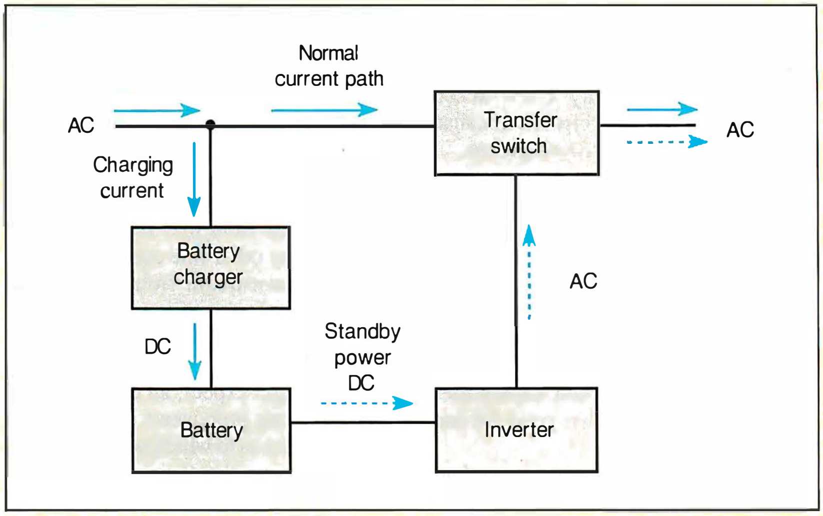


Figure A: *The block diagram of a standby power system.*

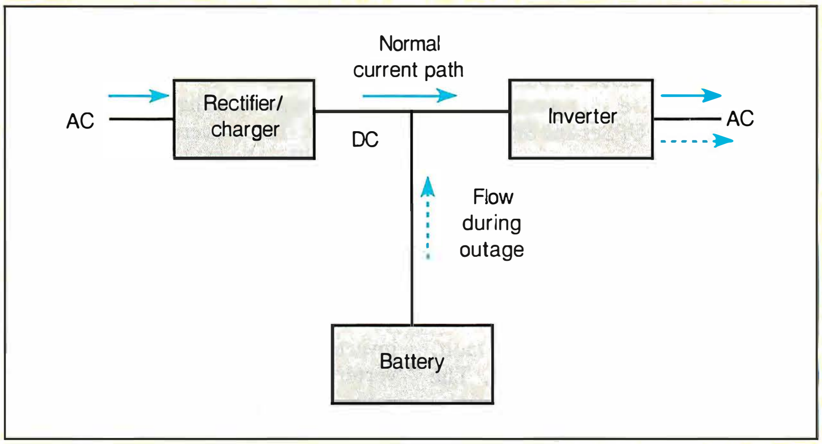


Figure B: *The block diagram of a true on-line UPS.*

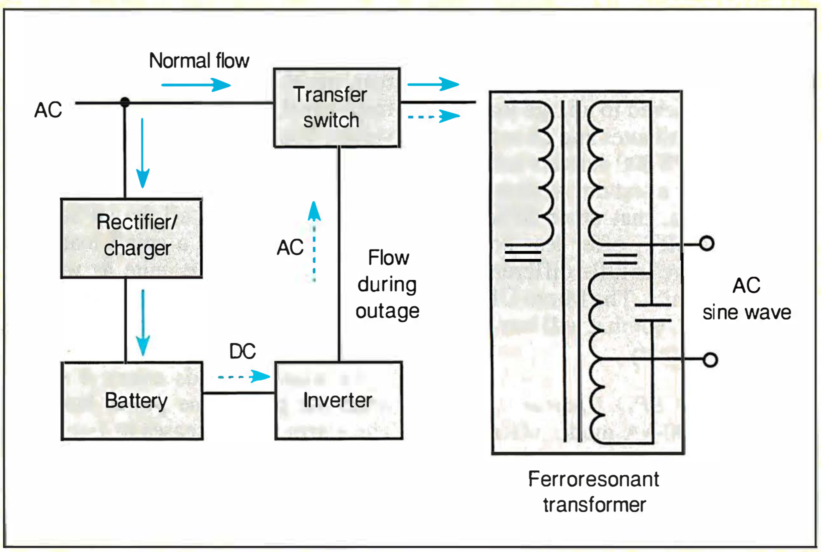


Figure C: *The block diagram of a ferroresonant UPS.*

mode spike of high magnitude will almost always affect the power supply of the microcomputer. However, a common-mode spike of only a few dozen volts can blow out logic circuits or cause soft errors between microcomputers.

Surge suppressors are good protection against normal-mode spikes, but their clipping action can cause common-mode spikes of even greater magnitude. Many SPSes tout surge protectors inside their units. Most experts agree that an SPS is an inadequate power conditioner. In fact, many manufacturers misrepresent the surge-suppression capabilities of their devices. SPSes are good for one thing: backup power.

On-line UPSes are hyped as excellent power conditioners. This is true only for normal-mode events. The double conversion process of the on-line design will suppress high-energy impulses appearing between line and neutral. However, the on-line design does nothing to prevent common-mode impulses from getting to sensitive equipment. As a matter of fact, all UPSes and SPSes generate significant common-mode noise. Far from conditioning power, UPSes become the culprits.

A transformer solves this problem. A transformer has its neutral and ground bonded together, shorting out common-mode noise. The transformer itself can be part of an excellent design to thwart normal-mode events.

The ferroresonant design is a good power-line conditioner for both normal-mode and common-mode events. This makes the SPS/ferroresonant design a good choice from that standpoint. But you can buy other line conditioners that plug in downstream from an SPS and provide similar benefits.

Switching Off

As you might expect, an ongoing battle wages among proponents of the various technologies as to which is best. The on-line people say that theirs is the best because the inverter is on-line all the time. Thermal stress is not a worry since they are not "cold-starting" the inverter when utility power fails. The standby manufacturers say that theirs is more reliable since the inverter is on only when power is out.

Both arguments have the ring of truth to them. The concern is not which design philosophy to agree with. The real question is how well did the company engineer the system. If an SPS is not designed to pick up the load gracefully, the most reliable components in the world will fail. On the other hand, *if the* on-line unit is not carefully engineered, thermal stress will cause premature failure while the unit is running.

Also, inverter design is not the Achilles' heel of any UPS. Two far more important factors are quality control and batteries. Many small UPSes are manufactured overseas, usually along the Pacific Rim, and they are shipped to the U.S. in boxes that are never opened and never checked. This can result in rates of initial failure of over 5 percent. One firm even found a pair of pliers inside a failed SPS. An even more common trouble area is batteries—the single most frequent point of failure for any UPS.

There is virtually no limit to the variations of the uninterruptible designs presented here. Expect to see hybrids, innovations, and exceptions. But a working knowledge of the basic designs shown here will prepare you for some of the more creative options that you might discover.

Mark Waller is a computer facilities consultant and the author of Computer Electrical Power Requirements *and* Mastering PC Electrical Power, *both published by Howard W. Sams. He can be reached on BIX c/o "editors."*

nostic indicators for site-wiring fault, voltage level, and load thresholds. The battery kicks in at 101 V and maintains a consistent sine-wave output for over 40 minutes while connected to a small load. A continuous alarm alerts you when the Micro UPS 800 is approaching shutdown, and the unit transmits a warning message from the rear interface port (this port is identical to the 800RT's network port). Attached to a large load, the battery lasted 7 minutes and 28 seconds.

The Micro UPS 800 delivers sufficient performance for a standby system. Keep in mind, though, that other SPSes, including the 800RT, offer less cost per VA. In fact, there is little difference between the two units. The Micro UPS 800 costs $100 more, but that will buy you an extra year's warranty.

General Power EPD Unistar U1000: This sturdy 1000-VA model offers continuous on-line protection for $2699. The unit boasts consistent sine-wave output, top-notch battery capacity, spike suppression, noise filtering, and overload protection.

The front-panel line input light glows green when AC power is available. The inverter output light indicates proper inverter operation. An amber bypass indicator lights when the bypass source is providing output power. Finally, a red fault indicator warns of system overload, battery depletion, or inverter failure.

You can manually transfer from the inverter to bypass power using the unit's off/reset button. While a switch on the rear panel controls master power, the front-panel on switch activates the inverter. You are limited to three rear output sockets.

This heavy-duty unit posted the longest holdup time of all the UPSes tested when connected to a small load. However, it did not fare quite as well with larger loads, finishing in second place on the moderate-load test and third on the large-load test.

An alarm sounds every 4 seconds when the power-line power has failed. The alarm rate increases to 1-second intervals when shutdown is imminent. The powerful battery and on-line design deliver maximum protection, consistent output, and reliability. The unit comes up short on sockets and network connectivity, but that does not denigrate its impressive credentials.

ITT PowerSystems VIP 800: This $1699 UPS comes from a manufacturer with a solid reputation for quality; the VIP 800 is unlikely to damage that reputation. It's a compact, lightweight design that delivers 800-VA capacity, a smooth sine wave, uninterrupted power, and very respectable holdup times.

Our undervoltage tests produced no noticeable effect on the output of the on-line system. The VIP 800 continued its steady sine-wave output despite long- and short-term interruptions. Holdup time was better than that of any other 800-VA unit we tested.

The front panel has a power switch, LED bar graphs for load and charge, and alarm LEDs. The small, light, rectangular design makes it suitable for desktop or floor-standing operation.

In terms of VAs per dollar, the VIP 800 is the least expensive on-line/sine wave unit we reviewed. Its reliable power and good capacity make it worth consideration for any application with compatible load requirements. If we have one complaint about this system, it's the continuous alarm that sounds at power failure (most UPS alarms are intermittent).

continued

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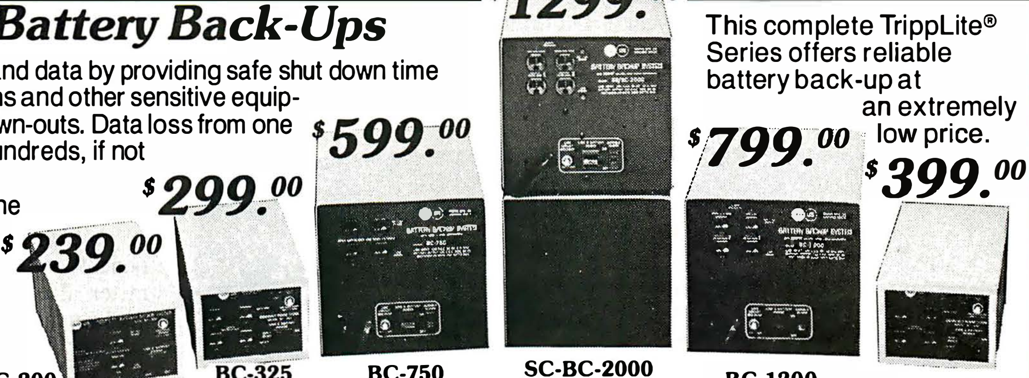
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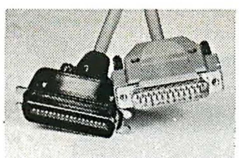
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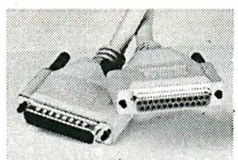


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The noise can be very distracting if a failure occurs and you choose to work for a few minutes before shutting down.

Kalglo Electronics Line-Saver LS-750: The Line-Saver delivers standby protection to a 750-VA load for $995. The unit boasts a low price and has a two-year warranty, but its battery capacity is low, and it does not generate a true sine wave.

A traffic-light icon displays the system status on the front panel. The green light confirms proper AC operation. The yellow light illuminates when the inverter is on and blinks increasingly fast as the battery depletes. When the load is too heavy or the battery is extremely low, the red light warns of imminent shutdown. An intermittent alarm also becomes steady at this point. The rear panel contains a pair of outlets and an external DC input. The unit supplies noise filtering and surge suppression, but a network interface is optional.

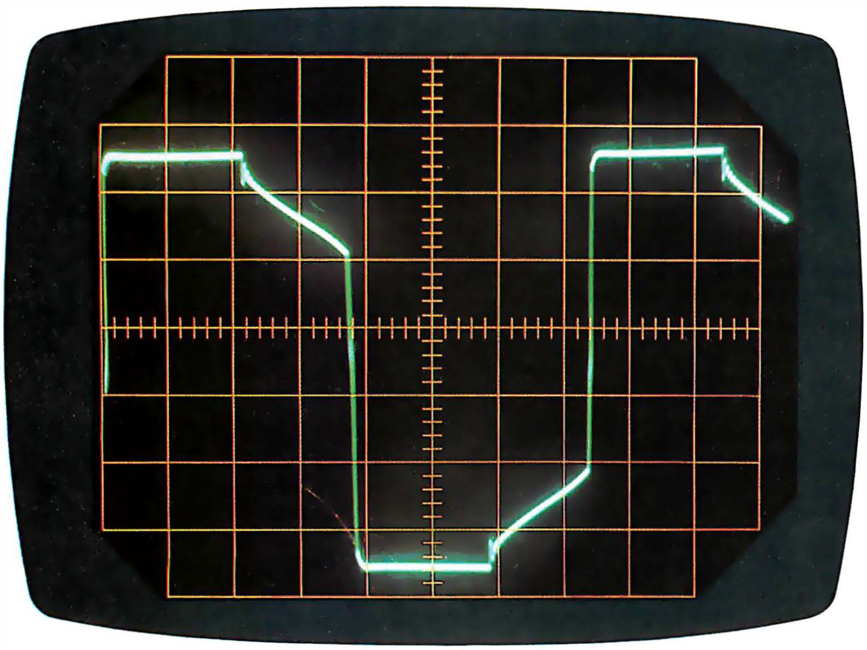


Photo 3: *The Kalglo Electronics Line-Saver LS-750 modified square wave.*

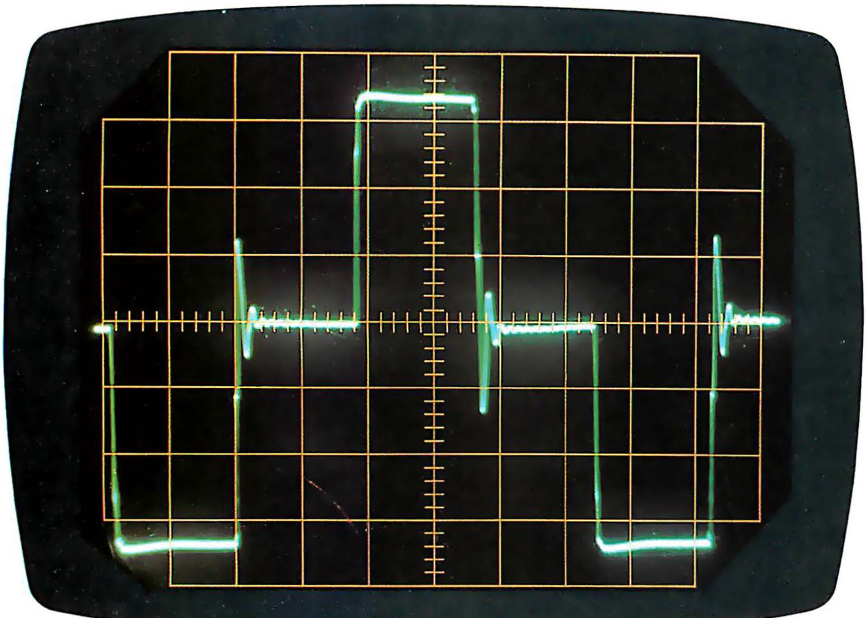


Photo 4: *The Unison Stepped Square wave, another sine wave approximation.*

When AC power fails, the Line-Saver produces a pulse-width-modulated waveform with an RMS voltage equivalent to the line. We discovered some problems when the unit faced degraded conditions within 30 percent of normal. The inverter did not switch as cleanly as it did when handling a full-cycle wave during our near-blackout test. In any case, the transfer time was the longest of any standby system we tested (see photo 3).

Some equipment will not work well with a full-cycle wave, but this unit had no problem with the wide range of components we plugged into it. Our RMS meter also registered high output voltages when the Line-Saver switched to the inverter. (Kalglo claimed that this was a natural effect of computers' switching power supplies.)

The Line-Saver LS-750, a small box with a surprisingly high VA rating, suffers from some significant drawbacks. It posted the longest transfer time and shortest battery life of the units tested. We'd also like to see a true sine-wave output. It simply can't compete with other systems in its price range.

Sola Electric Mini UPS/2: As its $3712 price suggests, the Mini UPS/2 belongs in a different class than the other units reviewed here. While it shares some of the same features, it also offers special protection. It is an on-line unit, rated at 1000 VA, that generates a consistent sine wave and delivers long battery life.

Front-panel indicators include battery OK, bypass, overload, battery low, and AC fail. The battery OK light blinks when the battery is recharging. When power fails, the red AC fail light illuminates, and an alarm sounds every 3 seconds. The unit beeps more frequently when it approaches shutdown, and it attempts to alert connected equipment through the RS-232C interface at the rear of the unit.

The RS-232C interface also returns vital status data when prompted from a host computer. The host can request such information as battery voltage, input voltage, output voltage, output current, and excessive temperature readings. The rear panel also includes four outlets, a master circuit breaker, and external battery connections.

The Mini UPS/2 attains true output isolation with a built-in shielded isolation transformer. Line frequencies as low as 40 Hz will continue to charge the battery, even with a full load. A static transfer

continued

Pop Quiz.

Stop. This is a test. For the next 60 seconds, we will be conducting a quiz about Macintosh® II Videographics. Do not turn the page until you have looked at the visual clue and answered all the questions.

Which Macintosh II graphics card offers the widest range of capture and display resolutions–NTSC, PAL, Apple® Monitor, hi-res, interlaced, non-interlaced and other modes?

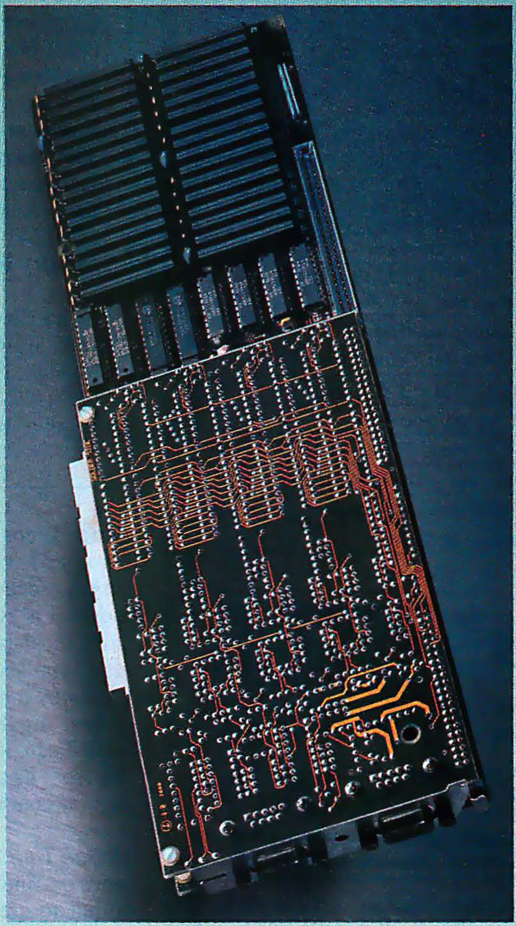
a) NuVista 2M   b) NuVista 4M   c) All of the above

Name the only videographics card which provides true-color, real-time capture *and* broadcast-quality display while occupying only a single slot in a Macintosh II.

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switch keeps the inverter frequency synchronized with the AC line. If start-up surges exceed the inverter's capabilities, the load is switched to bypass without a shift in phase or frequency. This UPS also supplies noise filtering, spike suppression, and short-circuit protection.

For rugged applications, the Mini UPS/2 can do the job, but users will benefit from its sophisticated design even for regular computer loads.

Unison UniPower DP 800: Unison combines on-line operation with square-wave output to create the UniPower DP 800. Its unique design makes the DP 800, listed at $995, one of the two least expensive on-line systems we reviewed.

Like the $995 Emerson PC/ET, this 800-VA unit is designed as a flat box, which is suitable for placement between the system unit and the monitor. On/off switches are provided for the four backed-up and four bypassed power outlets. The UPS also has lights that illuminate the keyboard during power failure, solving a not-so-obvious problem associated with shutting down a system during a blackout.

As an on-line unit, the DP 800 showed no output effect when hit with brownout voltages. On the downside, holdup capacity is limited; the unit had the weakest holdup times among the 800-VA units and was even outperformed by some of the 750-VA units.

The biggest question mark in evaluating this unit is its unusual output waveform (see photo 4). The wave is designed to supply power the same way a switching power supply demands it: in discrete

continued

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*)Common Windows is a windowing standard for Common Lisp proposed by Intellicorp, Inc. IntelliCorp is a trademark of IntelliCorp Inc. ExperTelligence is a trademark of ExperTelligence Inc.

gulps at waveform peaks. The 115-V RMS and 170-V peaks are close to the figures for a sine wave, so linear loads accept it as well. As with any nonsine wave, however, the short-duration square wave provides additional harmonics that can stress loads expecting a sine-wave input.

Viteq Benchmark Model 386/LAN: The 386/LAN falls in the middle of the pack on most of our measures of price and performance. Rated at 750 VA and selling for $1895, it does not quite reach the high-priced realm of the Computersave Mark II, but it does not qualify as a low-cost power solution, either. The 386/LAN features on-line operation, a network interface, and sine-wave output for a moderate price.

Our 30 percent sag tests generated no disturbance in the output waveform. In fact, the 386/LAN's output RMS voltage wavered only ½ V under all our test conditions, well within our margin-of-measurement error. Holdup time was average for the unit's rating, but recharge time was quite good. Short recharge time can be a valuable asset if power failures are relatively frequent.

The system features a relatively compact design and front-panel LED bar graphs for load and charge indication. There is also an audible alarm and a network interface connector (compatible with Novell and Banyan file servers), from which the 386/LAN gets its name.

The Supplies in Demand

Selecting a UPS depends heavily on the load you are trying to protect. As with any purchasing decision, inevitable trade-offs emerge. On-line operation ensures greater protection, but the usable lifetime of the battery may be reduced, since it's always in operation. And you have to pay for the on-line design. True sine-wave output is desirable over modified square waves, but you'll have to pay for that, too. Extra features like network interfaces are nice, even prerequisites in some situations, but you'll . . . well, you get the picture.

The Sola Electric Mini UPS/2 attains Cadillac status. If you aren't too concerned about price, and absolute top-notch protection is your principal goal, you can't go wrong with the Mini UPS/2. We thought that, even with all its perks, it was just too expensive, given the scope of this roundup.

The Emerson PC/ET has a nice price tag for an on-line system, and it performed valiantly on our tests. We liked the sleek design and ease of operation. Only the low VA rating holds it back, but for single-system protection, it's a solid choice.

Our favorite system of the bunch was ITT PowerSystems' VIP 800. It provides all the features required in a quality UPS: sine-wave output, on-line operation, and good holdup time. Its price-to-power ratio also makes it attractive to those concerned with cost as well as quality. And when the lights dim, you can breathe a little easier, knowing that your investment has indeed paid off. ■

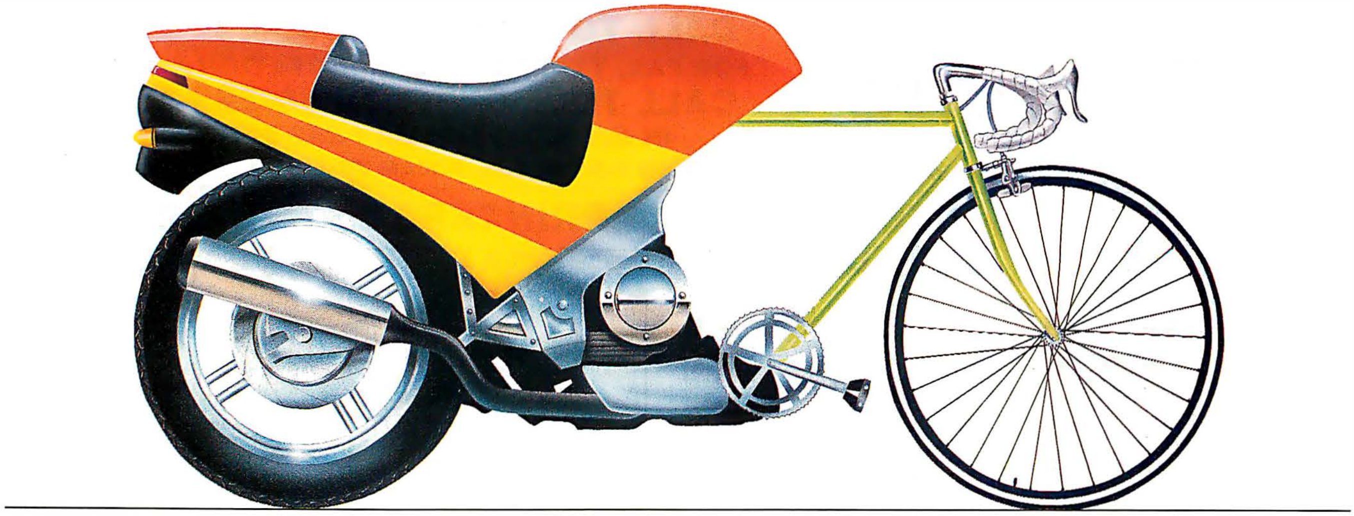
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Steve Apiki and Stanford Diehl are BYTE Lab testing editors. Rick Grehan is the director of the BYTE Lab. They can be reached on BIX as "apiki," "sdiehl," and "rick_g."

Circle 40 on Reader Service Card

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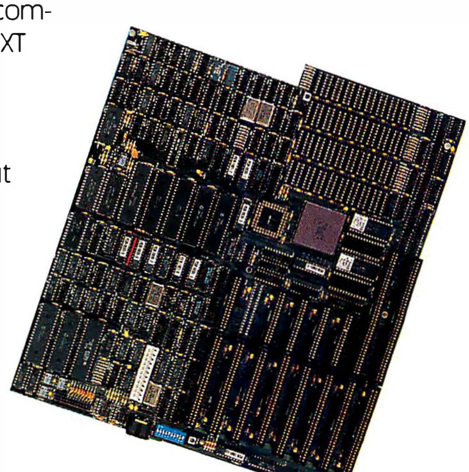
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DTK's new PEM-2000 dual-speed 8/20 MHz 80386 motherboard gives you 100% PC/AT compatibility at speeds up to 27.3 MHz. It also offers some very elegant engineering, like eight expansion slots including two for 32-bit memory expansion, two serial ports and one parallel port, a DTK BIOS with built-in diagnostics, and the socket for an optional 80387 coprocessor.

DTK means value in PC-compatible motherboards, add-on and networking cards, and bare bone systems, including FCC Class B-certified 10 and 12 MHz '286 computers. Which is why the two high-speed XT clones named "Best Buys" in *PC World*'s August, 1988 issue, both use DTK motherboards.

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High-Tech Computing, Cafeteria Style

The Wells American CompuStar 286 packs performance into a design-it-yourself PC

Mark L. Van Name



When it comes to PC engineering, "new" usually means bigger or faster: faster processors, bigger and faster memory caches, bigger and faster hard disk drives. That's why it's nice to see a computer like the Wells American CompuStar 286—a machine that tries something new.

What's new about the CompuStar is that it's the first computer designed to be whatever kind of PC you want. Want an AT clone? The CompuStar can be an AT clone. How about a Micro Channel system—a PS/2 clone? It can be that, too. You can even have both types of PCs in the same box.

You pick your processor, too. You can choose an 8086, a fast 20-MHz 80286, or three different models (16-, 20-, and 25-MHz) of the 80386.

The Secret

The secret to this flexibility is a unique design. The CompuStar base system includes a keyboard and an almost-empty shell: a 24- by 7½- by 26-inch, floor-standing, aluminum-skinned case housing just a 220-watt power supply and what Wells American calls its I/O module. The I/O module supplies two serial ports, one parallel port, PS/2-style 6-pin DIN keyboard and mouse connectors, and both a DB-9 digital monitor connector and a DB-15 VGA analog connector. Circuitry on the I/O module handles VGA (courtesy of a Paradise PVGA1A chip), EGA, CGA, MDA, and Hercules graphics. This board also acts as a disk drive controller that can handle up to four floppy disk drives.

After you order the $1195 base system, you then choose from a list of options. You start with a bus module. You can pick an AT- or PS/2 Micro Channel–compatible bus module; if you choose the PS/2 bus module, you also need a special PS/2 adapter. The AT bus module has seven AT-compatible expansion slots, while the PS/2 module contains five Micro Channel–compatible slots and one AT-compatible slot. Since the only card you need to add to most CompuStar basic systems is a hard disk drive controller, you end up with a lot of free slots.

And there's more. You can have not one, but two bus modules—a primary and a secondary. You can mix and match these any way you want: two AT bus modules, two PS/2 bus modules, or one of each. So, in a single CompuStar chassis, you can have up to 13 AT slots, or 10 PS/2 slots and one AT slot, or a mixed bag of seven AT slots and five PS/2 slots. Talk about expansion space!

After you pick a bus module, you then need to choose a processor, or, in Wells American's terms, a CPU module, which contains a CPU, a socket for a math coprocessor, memory sockets, the ROM BIOS, sockets for two expansion ROM chips, and a battery-backed clock/calendar. Wells American is shipping the 80286 and both 16- and 20-MHz 80386 CPU modules. A company spokesperson said that the 10-MHz 8086 CPU module was scheduled to begin shipping in February.

continued

Wells American also offers a nifty CPU upgrade option. You can trade in your initial CPU module for another and get a purchase credit toward the cost of the new one. In fact, if you trade in your CPU module within a year after purchase, the company gives you its full purchase price as a credit.

The combination of the bus and CPU modules still doesn't give you a complete system. While the 8086 CPU module comes with 512K bytes of memory, the 80286 and 80386 CPU modules do not include any memory. You purchase separately either 512K-byte or 1-megabyte memory modules from Wells American. These memory modules are 80-nanosecond DRAM zig-zag in-line packages (ZIPs) that plug into the eight ZIP sockets on the CPU modules. You can add a 1-megabyte memory-expansion kit to the 1-megabyte memory modules, so, with eight such expanded modules, you can rev your CompuStar up to its maximum 16 megabytes of memory.

Finally, you must add the other necessities: one or more floppy disk drives, one or more hard disk drives, a monitor, and DOS.

This process sounds like a lot of work, but fortunately Wells American sends the system to you fully assembled, with the hard disk drive formatted and ready to go.

A Cautionary Note

If the CompuStar's flexibility, and especially its dual-bus option, seem too good to be true, you're not alone. I felt the same way. I'm still not sure it will all materialize, because as we go to press, Wells American is not yet shipping any of the PS/2 modules, and the company did not get an 80386 CPU module to BYTE in time for this review because it was only recently completed. A spokesperson said that the PS/2 modules were ready, but that Wells would not ship them until it had secured some patents it was seeking. The company projects that it will ship the PS/2 modules in the first quarter of this year.

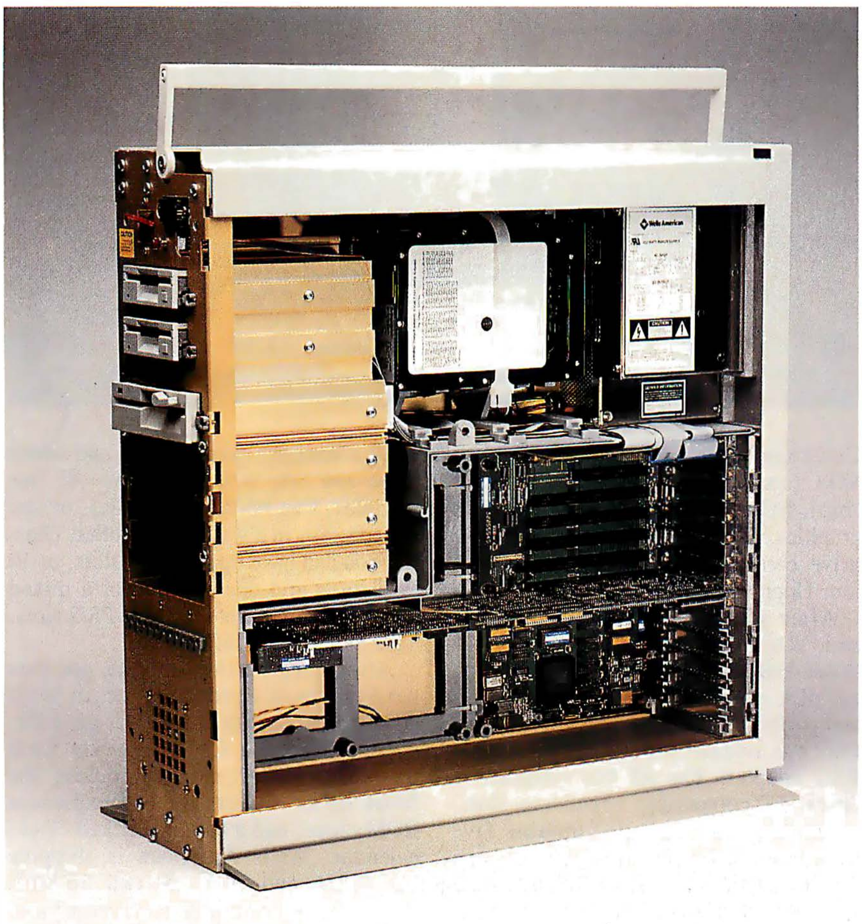


Photo 1: *The inside of the CompuStar reveals the nature of the beast: plenty of expansion room and easy access to components.*

Despite the unavailability of some modules, this machine shows some of the nicest engineering I have seen in a long time. Although Wells American isn't a household name, the company has been around for some time. In the late 1970s and early 1980s, it built microcomputers under the name of Intertec Data Systems, which you may remember for its SuperBrain CP/M microcomputers and its later multiuser systems.

The Evaluation System

My evaluation system came with one AT-compatible bus module, the 20-MHz 80286 CPU module, a 10-MHz 80287 math coprocessor, 1 megabyte of 80-ns DRAM in two 512K-byte ZIPs, two 1.44-megabyte 3½-inch floppy disk drives, one 1.2-megabyte 5¼-inch floppy disk drive, a 150-megabyte hard disk drive, a flat-tension-mask VGA color monitor, and IBM's PC-DOS 3.3. Six of the AT slots were empty, with the hard disk drive controller in the seventh slot (see photo 1).

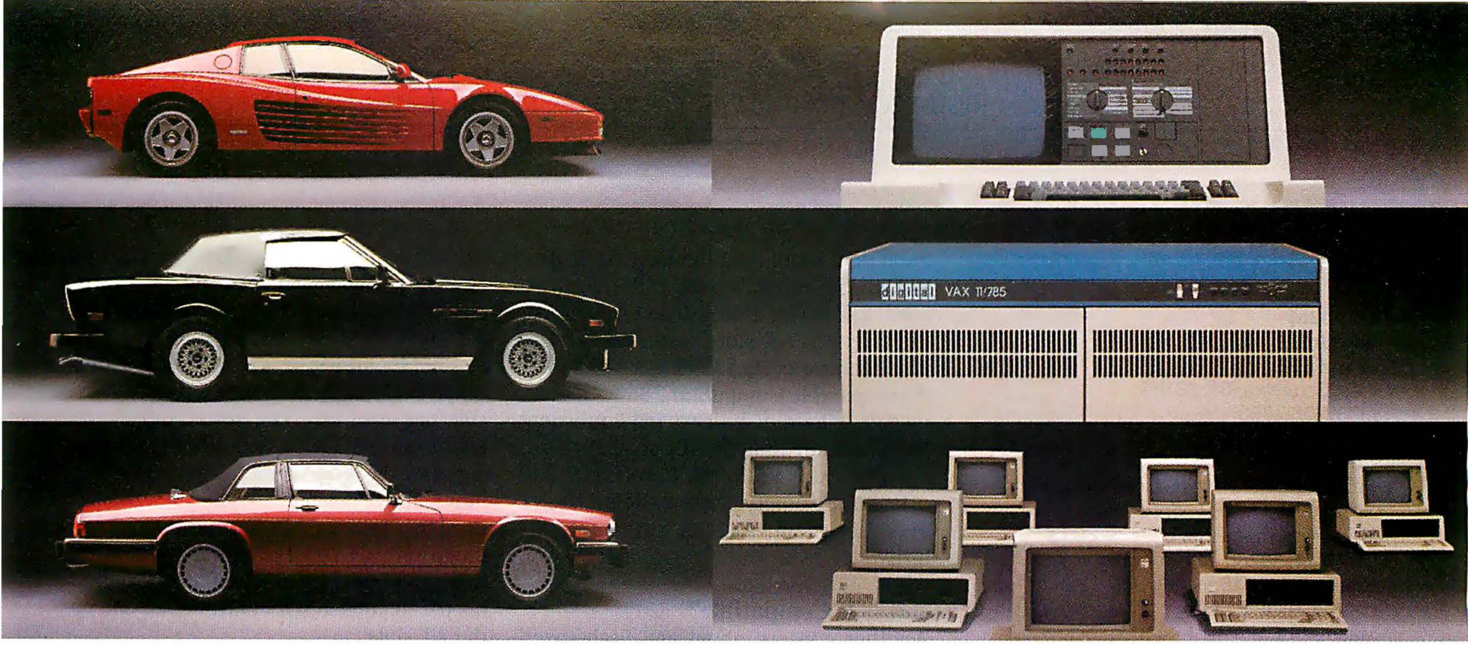
That's a powerful system, and it carries a hefty price tag: $6570. But you get a lot of performance for the money. In fact, this CompuStar 286 proved to be the fastest 80286-based system that BYTE has tested. Its overall application index was about 9 percent faster than that of the previous 80286 speed champ, the Dell System 220. The CompuStar beat the Dell System 220 on all but the word processing and compiler tests, which it lost by only 3 percent and 2 percent, respectively.

Both systems maximize their performance with interleaved memory banks, so that one bank of memory recharges while the other is ready to go. As you might expect from such a well-engineered machine, the CompuStar offers a nice improvement on traditional two-bank interleaving: If you have four identical memory modules, it can do four-way interleaving, so that three banks are ready while one is recharging. On its 80386-based CPU modules, Wells American combines this interleaving with an Intel 82385 cache controller and 32K bytes of 35-ns static RAM cache to boost performance further.

Wells also borrows a page from most 80386-based systems for the CompuStar 286 by using shadow RAM, a technique that copies the ROM BIOS into RAM at boot time for faster ROM access.

The flip side of performance is always price, and the CompuStar's speed victory over the Dell System 220 would mean a lot less if the CompuStar cost a

continued



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CompuStar 286

Company
Wells American Corp.
3243 Sunset Blvd.
West Columbia, SC 29169
(803) 796-7800

Components
Processor: 20-MHz 16-bit Intel 80286; 10-MHz Intel 80287 coprocessor
Memory: 1 megabyte of 16-bit 80-ns DRAM on 80286 CPU module, expandable to 16 megabytes; 128K bytes of BIOS ROM
Mass storage: Two 1.44-megabyte 3½-inch floppy disk drives; one 1.2-megabyte 5¼-inch floppy disk drive; 150-megabyte hard disk drive
Display: Flat-tension-mask color VGA-compatible monitor; VGA support on the motherboard
Keyboard: 101 keys in IBM Enhanced layout
I/O interfaces: Two RS-232C serial ports; DB-25 parallel port; analog monitor port with DB-15 connector; 6-pin DIN keyboard connector; 6-pin DIN mouse connector; seven AT-compatible expansion slots

Size
24 × 7½ × 26 inches; 66 pounds (weight can range from 50 to 90 pounds, depending on the configuration)

Software
Setup disk, which includes a setup utility, a memory and port management utility, a video mode utility, a utility for setting the processor's speed, utilities for displaying messages on the LED display, and drivers for LIM/EMS memory and additional floppy disk drives

Options
CompuStar Base Model 100: $1195
AT-compatible primary bus module: $195
AT-compatible secondary bus module: $175
PS/2-compatible primary bus module: $295
PS/2-compatible secondary bus module: $250
PS/2 adapter module: $995
8086 CPU module (available as of February): $295
80286 CPU module: $695
80286 memory-extender kit: $55
16-MHz 80386 CPU module: $1395
20-MHz 80386 CPU module: $1695

Documentation
User's manual; Adaptec hard disk drive controller user's manual

Price
System as reviewed: $6570

Inquiry 857.

great deal more than the Dell computer. A Dell System 220 with a 40-megabyte hard disk drive, 1 megabyte of memory, three empty AT slots, and Dell's VGA Plus monitor costs $3299 as I write this. A comparable CompuStar 286 with a 44-megabyte hard disk drive and equivalent VGA monitor runs $4010, or $711 more. For that extra $711, the CompuStar 286 offers more empty slots, a slightly faster overall system, and its built-in flexibility.

But Is It Compatible?

Another concern about any high-speed PC is its level of compatibility. The CompuStar ran everything I threw at it, both hardware and software. I successfully installed an Everex Evercom II 2400-bps internal modem, a Microsoft Serial Mouse, and an Intel Above Board/AT. On the software side, I tested Borland's Quattro 1.0, Reflex 1.14, SideKick Plus 1.0, SuperKey 1.16A, Turbo Basic 1.1, Turbo C 2.0, and Turbo Pascal 4.0; Digitalk's Smalltalk/V 1.2; Kermit 2.30; Lotus 1-2-3 version 2.01, which ran without forcing me to slow the system manually; MicroPro's WordStar 3.3 and 4.0; Microsoft's PC Paintbrush 2.0 and Word 4.0; Quarterdeck Office Systems' DESQview 2.0; the Norton Utilities 3.00; and Symantec's Q&A 1.1.

Wells American sells IBM's own PC-DOS 3.3 and the AT version of IBM's OS/2 1.00, which a Wells spokesperson said runs on the CompuStar. Wells did not include OS/2 with the evaluation unit, however, so I was unable to verify that.

And More Goodies

When you leave the world of external applications and dive into the box itself, you find that the Wells engineers have been at it again. It starts with the fans—one at the bottom front of the unit that blows out enough air that you can feel it if you wear shorts, and one at the top rear inside the power display case. The unit disassembles easily, using Nylatch nylon snap fasteners.

The flexible design also extends to the CompuStar's storage devices: The system can hold up to six half-height devices, all of which you can access from outside the machine, if necessary. Two of these device areas are 3½-inch bays, while the other four can hold 5¼-inch devices. All the devices mount on sliding rails inside the machine.

My evaluation unit had two Mitsubishi 3½-inch floppy disk drives, which DOS saw as drives A and B, in the 3½-inch slots. By using Wells's own special drivers and CompuStar Extended Diskette Drive BIOS, DOS saw my evaluation unit's third floppy drive, a 1.2-megabyte 5¼-inch TEAC model, as drive E.

The CompuStar also includes one other full-height 5¼-inch drive bay inside the machine. The power supply includes seven device connectors, so you can run the system even if you fill this bay and all six half-height bays. In my unit, this internal bay held a Maxtor 155-megabyte, 18-millisecond hard disk drive managed by an Adaptec 10-megabit-per-second ESDI controller in one of the AT slots.

Wells American includes Storage Dimensions' well-respected SpeedStor hard disk device driver, version 5.13b, with the system. The combination of that software and Wells's disk BIOS lets you make a second DOS partition that is larger than the traditional DOS 3.3 limit of 32 megabytes. In my evaluation unit, the C drive was only 2 megabytes, while the D drive was over 150 megabytes. Wells American uses this design to leave drives E and F open for two of the four floppy disk drives that the CompuStar can include.

Wells also offers a slew of other mass storage options, including tape backup systems, a WORM (write once, read many times) drive, and an erasable optical drive from Maxtor.

The CompuStar's interior bay design has one flaw: No hard disk light is visible outside the machine. Wells more than compensates for this omission, however, with a little touch that Dell popularized on its early systems: a four-character LED display on the front of the system. That display shows both diagnostic and system status information. For example, it shows "R" when the system is reading the hard disk and "W" when the system is writing to that disk. If you press the Control or Shift keys, the LED shows the current system speed.

Wells American also includes on its standard setup disk two programs, DISP.EXE and SCROLL.EXE, with which you can display four characters of your choice, either statically or scrolling from right to left, in the LED display.

Wells American also did its own ROM BIOS; my unit included the CompuStar Multi-Processor Convertible Microcomputer V1.05 BIOS.

Like most of today's fastest systems, the CompuStar offers a slower compatibility speed. Unlike many systems, however, it offers five slower speeds. You can run the 80286 at 16, 12, 10, 8, or 6 MHz. Wells implements these speeds by

continued

Wells American CompuStar 286

APPLICATION-LEVEL PERFORMANCE

Wells American CompuStar 286 **12.5***

WORD PROCESSING	
XyWrite III+ 3.52	**Medium/Large**
Load (large)	:10
Word count	:03/:20
Search/replace	:05/:22
End of document	:02/:14
Block move	:09/:09
Spelling check	:09/1:00
Microsoft Word 4.0	
Forward delete	:13
Aldus PageMaker 1.0a	
Load document	:13
Change/bold	:25
Align right	:20
Cut 10 pages	:18
Place graphic	:05
Print to file	1:46
Index:	**2.62**

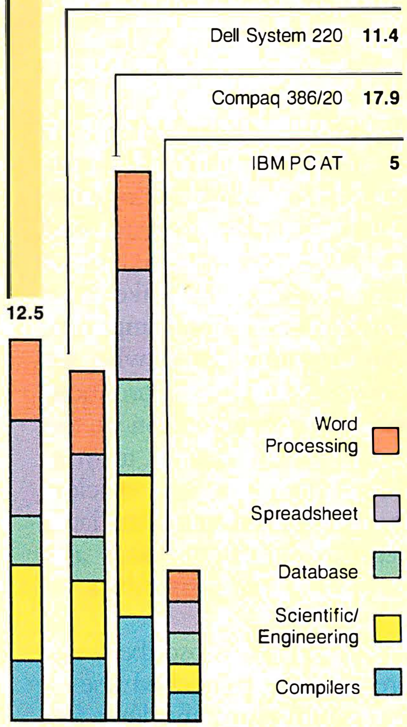
SPREADSHEET	
Lotus 1-2-3 2.01	
Block copy	:03
Recalc	:01
Load Monte Carlo	:16
Recalc Monte Carlo	:04
Load rlarge3	:03
Recalc rlarge3	:01
Recalc Goal-seek	:03
Microsoft Excel 2.0	
Fill right	:05
Undo fill	1:50
Recalc	:01
Load rlarge3	:25
Recalc rlarge3	:01
Index:	**3.11**

DATABASE	
dBASE III+ 1.1	
Copy	:59
Index	:18
List	1:14
Append	1:34
Delete	:02
Pack	1:20
Count	:16
Sort	1:04
Index:	**1.65**

SCIENTIFIC/ENGINEERING	
AutoCAD 2.52	
Load SoftWest	1:09
Regen SoftWest	:44
Load StPauls	:11
Regen StPauls	:07
Hide/redraw	14:58
STATA 1.5	
Graphics	:19
ANOVA	:14
MathCAD 2.0	
IFS 800 pts.	:21
FFT/IFFT 1024 pts.	:22
Index:	**3.06**

COMPILERS	
Microsoft C 5.0	
XLisp compile	4:37
Turbo Pascal 4.0	
Pascal S compile	:06
Index:	**2.06**

All times are in minutes:seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT=1.



*Cumulative application index. Graphs are based on indexes at left and show relative performance.

LOW-LEVEL PERFORMANCE[1]

Wells American CompuStar 286

CPU	
Matrix	5.20
String Move	
Byte-wide	40.40
Word-wide:	
Odd-bnd.	30.60
Even-bnd.	20.19
Sieve	22.69
Sort	18.95
Index:	**2.64**

FLOATING POINT	
Math	23.12
Error[2]	
Sine(x)	9.78
Error	
e^x	8.37
Error	
Index:	**2.04**

DISK I/O	
Hard Seek[3]	
Outer track	3.29
Inner track	3.33
Half platter	6.66
Full platter	6.68
Average	4.99
DOS Seek	
1-sector	8.47
32-sector	25.19
File I/O[4]	
Seek	0.11
Read	0.88
Write	0.78
1-megabyte	
Write	4.87
Read	5.02
Index:	**1.90**

VIDEO	
Text	
Mode 0	3.95
Mode 1	3.96
Mode 2	3.94
Mode 3	3.92
Mode 7	N/A
Graphics	
CGA:	
Mode 4	1.92
Mode 5	1.87
Mode 6	2.01
EGA:	
Mode 13	3.46
Mode 14	3.74
Mode 15	N/A
Mode 16	3.77
VGA:	
Mode 18	3.90
Mode 19	2.00
Hercules	N/A
Index:	**2.30**

CONVENTIONAL BENCHMARKS	
LINPACK	478.68
Livermore Loops[5] (MFLOPS)	0.46
Dhrystone (MS C 5.0) (Dhry/sec)	5000

N/A=Not supported by graphics adapter.

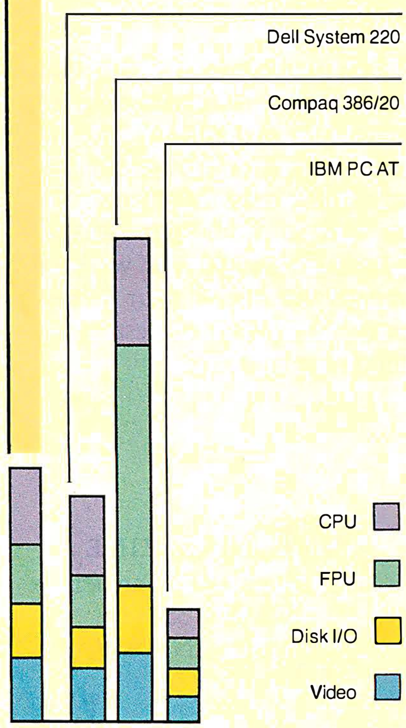
[1] All times are in seconds. Figures were generated using the 8088/8086 versions (1.1) of Small-C.

[2] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.

[3] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).

[4] Read and write times for File I/O are in seconds per 64K bytes.

[5] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.



For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks," June 1988 BYTE.

using three different crystals/oscillators in the system, one each for the 20-, 16-, and 12-MHz rates. A flip-flop divider off the oscillators provides the three additional slower speeds. You can control the unit's speed from the keyboard with the now-traditional Ctrl/Alt/+ combination to raise the speed, or Ctrl/Alt/– to lower it. The system beeps once each time you lower its speed, and twice each time you raise the speed. You can also use a Wells utility, SPEED.EXE, to set the speed from the DOS command line.

Monitor and Keyboard

In keeping with this abundance of options, you can choose either a "firm touch" or "soft touch" keyboard. Both keyboards follow the IBM 101-key Enhanced layout. My evaluation unit came with the Fujitsu keyboard that is showing up on a lot of machines these days. It has a good, very springy feel with an audible keyclick.

As for the monitor—well, if you haven't seen flat-screen color monitors yet, avoid them at all cost. Once you see one, you'll want one, and they're expensive. Wells charges $895 for the Zenith-built one on my evaluation unit, and it is gorgeous, albeit big and a bit noisy, since it has its own fan.

The Soft Side

The only standard software is Wells American's Setup disk, which comes in both 3½- and 5¼-inch versions. That disk includes Wells's setup program, which is also in ROM and accessible via the Ctrl/Esc key combination; a LIM/EMS driver; a program that lets you set the system's video mode; another that lets you control its port assignments and memory usage, including its use of interleaving and shadow RAM; Wells American's special disk drivers; and the LED and compatibility speed control programs mentioned earlier.

Documentation and Support

The CompuStar includes a single, 100-plus-page user's manual. Its early chapters are for novices, with step-by-step instructions for adding options to the system. Its later chapters and appendixes contain detailed technical information, including data on the jumpers on all the CPU modules.

Unfortunately, even though it's well done, this book just cannot make a novice comfortable installing all the possible options. The task itself is largely unnecessary, however, since Wells assembles the units at the factory.

My unit also came with a user's manual for my Adaptec hard disk drive controller. That complex book is useful only for skilled users who want detailed information about the controller.

When the manuals leave you wanting, you can call the company's technical support. It's a toll call, which is unfortunate since you're likely to have to wait. Every time I called, I had to sit on hold until I either gave up or gave in to the secretary's request for my name and number. When she took that information, however, someone always called me back. The support people with whom I spoke were courteous and very knowledgeable about every aspect of the system. In a rare sweep of competence, everyone with whom I spoke was able to answer all my test questions, which ranged from simple to complex.

You get a one-year limited warranty on parts and labor, which includes all hardware but not software. You have to get your machine, or at least the defective component, to a Wells Authorized Warranty Repair Center. You can buy on-site service in many locations nationwide through Wells's arrangement with General Electric. Wells American sets prices for this service on a monthly basis by component, such as $5 for the base system, $3.50 for the 80286 CPU module, and $26 for the 150-megabyte hard disk drive. Those prices can add up for a whole system; a year of service for my evaluation unit would run around $700.

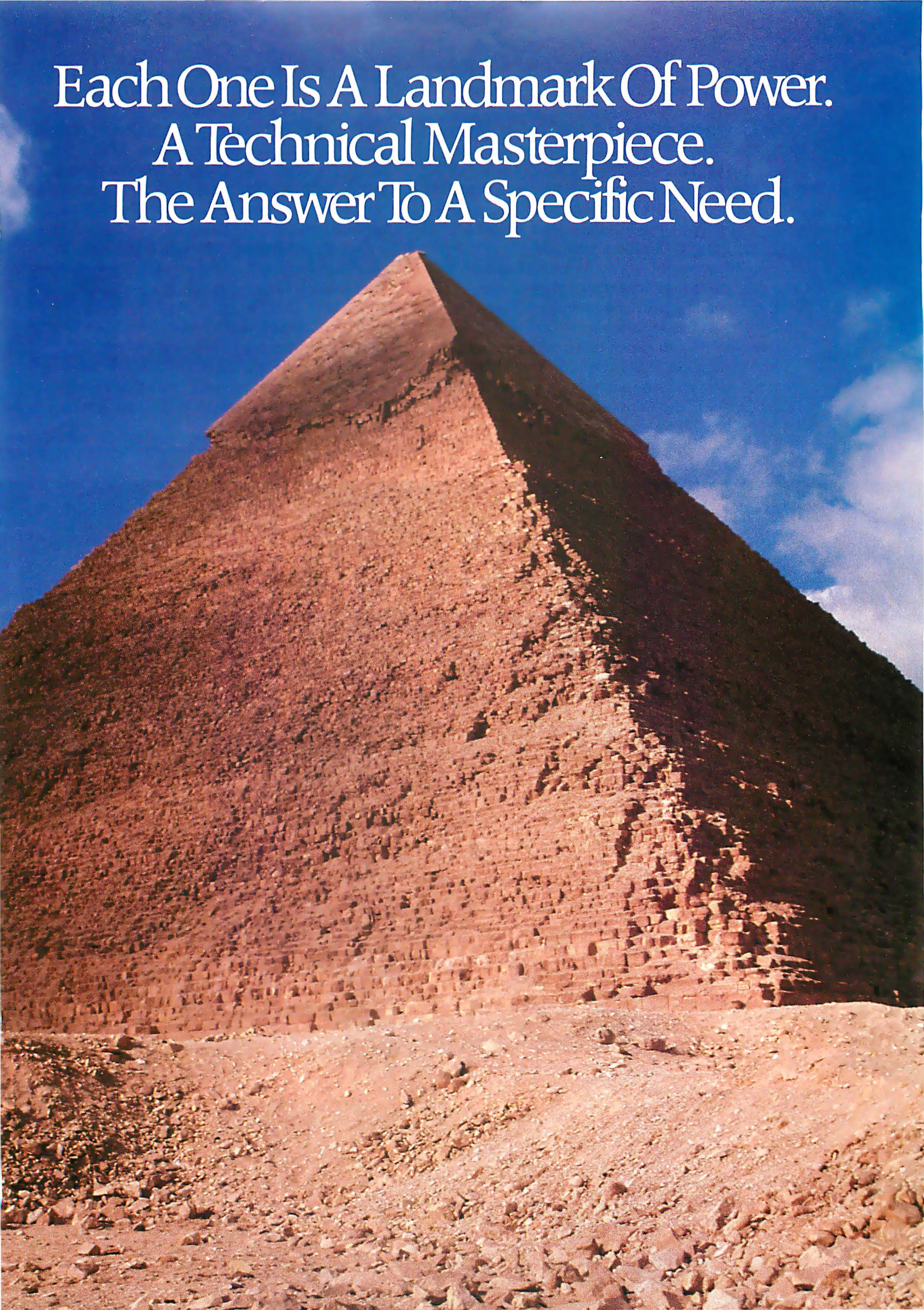
Wells offers another support plan, the C.A.R.E. (components authorized for repair or exchange) program, for which the company has not yet set prices. It lets you quickly replace a defective module. You call with the identity of the module, and the company will send a replacement via overnight delivery service.

A Good System with Great Potential

The CompuStar 286 is the fastest 80286-based system I've seen, and it has as much or more expansion capability as any system I've seen. Those properties, along with a bearable price tag, make it a good machine to consider. The real excitement will come if Wells American delivers its PS/2 module, fulfilling the dual-bus promise of the CompuStar.

I hope Wells meets this challenge, because I like this machine, and I like the engineering behind it. It's nice to see something new in the PC clone business for a change. ■

Mark L. Van Name is a freelance writer and computer consultant living in Durham, North Carolina. He can be reached on BIX c/o "editors."


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Full-Spectrum Scanners

The Sharp JX-450 and the Howtek Scanmaster bring affordable color scanning to the Mac II

Tom Thompson

Photo 1 *(below, left)*: *The Sharp JX-450 produces excellent results but requires a substantial amount of memory.*

Photo 2 *(below, right)*: *Howtek's Scanmaster offers superior scanning software on a hardware platform identical to that of the Sharp unit.*

The Mac II's rich set of color graphics primitives and its versatility at manipulating color bit maps make it a powerful image processor. But to take advantage of these capabilities, you've got to get the color images into the computer in the first place.

While you can do this easily enough in shades of gray with existing scanners (see "Bringing the Outside World into a Macintosh" by Laurence H. Loeb, October 1988 BYTE), the ability to achieve this result in color has been a long time coming. That's not to say that it couldn't be done, but the equipment to do it cost dearly—usually tens of thousands of dollars.

Now two vendors, Sharp Electronics and Howtek, have introduced scanning packages that can electronically reduce a color photograph to binary data and convert it into color formats that many Mac II applications can use (for a detailed description of how these scanners capture an image, see the text box "Color Scanning Explained" on page 191). Both packages accomplish this operation in just minutes. But their most important feature is their nonstratospheric prices: Sharp's top-of-the-line JX-450 color scanner package costs $7565, and the Howtek Scanmaster package is priced at $8195. Both scanners also work with the IBM PC and PS/2s.

Mirror Image

It's no coincidence that the Sharp and Howtek scanners look alike: With the exception of the company nameplate, both scanners are identical. Howtek buys its scanner from Sharp and resells it with its own interface board and scanning software (see photos 1 and 2).

The scanners closely resemble a flatbed copier, right down to the hinged cover that holds the original down on the

continued





Sharp JX-450

Type
Flatbed color scanner

Company
Sharp Electronics Corp.
Sharp Plaza
Mahwah, NJ 07430
(201) 529-9500

Features
Scans images up to 11⅝ by 17 inches at 75, 100, 150, 200, and 300 dpi in 24-bit color; optional mirror unit lets you scan transparencies up to 8¼ by 11⅝ inches; can be programmed to scan in resolutions as low as 30 dpi in single steps up to 300 dpi; can scan images at several speeds and degrees of sharpness; PixelScan software drives scanner in various modes and saves images in several formats

Size
21¾ × 20⅞ × 7$\frac{5}{16}$ inches; 55 pounds

Hardware Needed
Macintosh II or IIx with at least 2 megabytes of RAM and a 40-megabyte hard disk drive; NB-GPIB package, which contains NB-GPIB NuBus board, driver software, and GPIB cable

Software Needed
Finder 6.1/System 6.0.2 or higher

Options
Mirror unit to scan transparencies: $500
NB-GPIB package: $570

Documentation
Programming manual

Price
$6995

Inquiry 851.

Howtek Scanmaster

Type
Flatbed color scanner

Company
Howtek, Inc.
21 Park Ave.
Hudson, NH 03051
(603) 882-5200

Features
Scanner unit characteristics are identical to the Sharp Scanner; also includes NB-GPIB NuBus board, software driver, and cable; MacScan-It application drives scanner in various modes and saves captured image in several formats

Size
21¾ × 20⅞ × 7$\frac{5}{16}$ inches; 55 pounds

Hardware Needed
Macintosh II or IIx with at least 2 megabytes of RAM and a hard disk drive

Software Needed
Finder 6.1/System 6.0.2 or higher

Options
Transparency scanning option: $659

Documentation
Operator's guide; MacScan-It user's guide; GPIB installation guide

Price
$8195

Inquiry 852.

image table. Markings on the sides of the image table let you accurately position eight different sizes of documents: U.S. office, legal, invoice, and tabloid, plus the European A3, A4, B4, and B5 standard sheets. If you want to scan slides or transparencies, Sharp's optional mirror unit or Howtek's transparency option must be attached to the scanner so that it redirects the light from the scanning lamps through the film.

Both scanners use an IEEE-488 general-purpose interface bus to communicate with the host computer. This means that, in addition to the scanning unit, GPIB interface hardware is required. Both products use the National Instruments NB-GPIB NuBus board, the NI-488 driver, and a GPIB cable to complete the connection. Finally, you'll need application software that talks to the scanner, retrieves the image data, and saves this information in a disk file. I call this combination of hardware and software a scanning package, since all the components in the package are required to obtain a scanned image.

You don't always get a complete scanning package when you buy a scanner. Howtek provides its Scanmaster scanner, power cable, and scanning software, along with the NB-GPIB interface board, driver software, and interface cable, as a complete package. Sharp, however, sells its JX-450 scanner, power cable, and scanning software as a unit for $6995. To connect the JX-450 to the Mac II, you need to buy the GPIB interface board, driver software, and interface cable for an additional $570.

Workspace Required

You'll need plenty of desk space or a large open spot on your office floor to accommodate these scanners. Measuring 21¾ by 20⅞ by 7$\frac{5}{16}$ inches, they each occupy more space than an IBM AT. The large size is necessary to accommodate up to a 12- by 17-inch document. You'll also need an additional foot of clearance on each side of the scanner, as the scanning bed moves from side to side during operation. Fortunately, the 6½-foot-long GPIB interface cable lets you place the scanner some distance away from the computer.

To take full advantage of these two scanners, you're going to need a hefty amount of resources. The Mac II you intend to use should have at least 2 megabytes of RAM and a high-capacity hard disk drive (I recommend at least 8 megabytes of RAM and a 100-megabyte hard disk drive). Images with 8-bit-deep color pixels need lots of RAM and disk space, so the more RAM and the larger your hard disk drive, the better off you'll be.

As with most Mac II NuBus peripheral boards, installation is a breeze. First, you pop the Mac II's hood, drop the NB-GPIB interface board into an empty slot, close the computer, and reboot. Then you copy the `NB Handler INIT` file to the Mac's System Folder. This INIT contains the NI-488 driver, which installs into the Mac II's system heap when you reboot the machine. Applications that work with the scanner use this driver to communicate through the GPIB interface. If you have more than one GPIB board in your system, the `ibconf` application written by National Instruments and supplied with both scanning packages lets you configure the `NB Handler INIT` for a particular board in the system.

All that's left is to copy the scanning application to the Mac II's hard disk, and you're set. Sharp provides a PixelScan application that can operate the scanner at various resolutions and scanning speeds and save the image in several data formats. Howtek's MacScan-It application has similar features, but it has better color controls and can save data in a wider range of data formats.

Once system setup is complete, you place a photo or document onto the scanner table and switch the unit on. After the scanner warms up, you launch the scanning application. First you select the

scanning mode, resolution, and color palette, and then you issue a scan command. The scanning bed moves from right to left, and in about 1½ minutes (at the fast scan setting), a color image fills the window of the scanning application. If you've set your color controls correctly, the results can be spectacular.

Not Created Equal

Although both scanning packages are virtually identical in terms of the scanning unit and GPIB interface, they differ significantly when it comes to the scanning software they supply. Sharp's PixelScan version 1.1a, written by SuperMac Software, provides only minimal capabilities. You can choose from a wide variety of scanning settings: resolution (36, 75, 100, 150, 200, or 300 dots per inch, or adjustable), image size (including U.S. and European formats), brightness correction (normal or lighter), scanning speed (slow, fast, or custom), and image sharpness (normal, sharp, exaggerated, or softened).

You can scan a picture using the Mac II system colors, custom color palettes, or gray scales. You can also specify whether you want dithering performed during the scan. For certain custom palettes, the scanner captures the image in two passes. The first examines the image's colors and then selects (from the Mac II's palette of 16.7 million colors) the 256 colors that best represent the image; the second pass performs the image scan. You can save the image in PICT2, PixelPaint, and MacPaint formats. PixelScan also has a SIZE −1 resource, making it MultiFinder-compatible.

The size and resolution of each scan is limited by available RAM. The only way you can control the size of the scanned area on the scanning bed is through canned document-size settings. The PICT2 file format is the graphics *lingua franca* for exporting color images to other Mac applications, but the MacPaint format, which handles only black-and-white images, makes no sense for a color scanner.

Although PixelScan operates under MultiFinder, it allows little or no background processing during a scan. I attempted an XMODEM download from BIX at 1200 bps using Red Ryder 10.3 in the background. The download timed out while PixelScan captured a large document.

Howtek's MacScan-It 1.0 is the more polished application, although the program and documentation was shipping in preliminary form (Howtek says it will provide free upgrades of the final version to users who buy the preliminary version). The program has the same image-size and image-sharpness menu selections as PixelScan. You can scan at resolutions of 75, 100, 150, 200, or 300 dpi, or at variable resolutions.

MacScan-It lets you scan an image as a positive or a negative, and with continuous colors or gray scales. If you're scanning transparencies or slides, MacScan-It has a large selection of color lookup tables for many types of films (e.g., Kodak, Konica, 3M, and Fuji). Unlike PixelScan, it also has a useful preview mode that lets you look at the image on the scanning table before starting the final scan. You can then resize a preview window to surround the picture entirely or crop the part that you want.

MacScan-It uses the preview window's dimensions to determine the area

continued

Color Scanning Explained

Sharp's color scanner is operationally similar to a gray-scale scanner. It measures the light intensity at certain points along the original image and converts this intensity level into digital values. However, a typical gray-scale scanner detects only 16 different light intensities (or shades), while the Sharp JX-450 scanner detects 256 different light intensities. And while a gray-scale scanner captures an image once, the Sharp scanner must do it three times, measuring the red, green, and blue intensities for each part of the image (for gray-scale images, the scanner uses only the green lamp).

The process is further complicated by the fact that all three RGB measurements must be aligned to the exact same points on the image. Otherwise, the combined color measurement would correspond to several different points on the image, resulting in color fringing or a garbled image. The process is similar to the careful alignment required to print a color picture like those in this magazine: If even one of the colored inks is printed out of register, the image is ruined.

Sharp's solution to this problem is ingenious. The original photo lies on the image table. The image table remains stationary while the JX-450 fires three colored fluorescent lamps (red, blue, and green) in sequence. Red and blue filters mounted over the red and blue lamps help to improve their spectral characteristics. This light then shines through a slit on the image table and onto a band of the image.

The light reflected from the image band is directed by two mirrors onto a charge-coupled-device (CCD) sensor strip. The strip contains 3648 photosensitive elements that measure the intensity of the light that falls on them. The sensor strip has sufficient elements to measure a band across the widest part of a European A3 document (297 millimeters, or about 11¾ inches) at 300 dpi. The light intensity for the particular color component (determined by the color of the lamp illuminating the image) is digitized into 256 levels (8 bits), although Sharp guarantees only 6-bit accuracy for each component.

The scanner sends the intensity information for the image band at this particular color to the host computer. Measurements of the next color component for the same band start when the next lamp fires.

Once all three lamps have fired and all the RGB color information for this image band has been captured, the scanning table moves slightly. This exposes a new part of the image, and the measuring process repeats. In this manner, the entire image is assembled, one band at a time. The only possibility for misalignment is if the scanning table moves inaccurately, but this only causes problems with the alignment of bands of the image, not with their colors.

To scan transparencies, the scanner uses an optional mirror box that directs light from the lamps through the film. Two mirrors in the device guide the light from the image table slit across the scanning table, through the film, and onto a third mirror inside the scanner. This third mirror then reflects the light onto the CCD sensor strip.

While this process might seem extremely complicated compared to the operation of a gray-scale scanner, the color scanner must capture three times as much information—all of it required to produce a realistic image. The Sharp scanner tackles this problem with a simple but effective design. The effort is worth it: The color images look worlds better than anything a gray-scale scanner could generate.

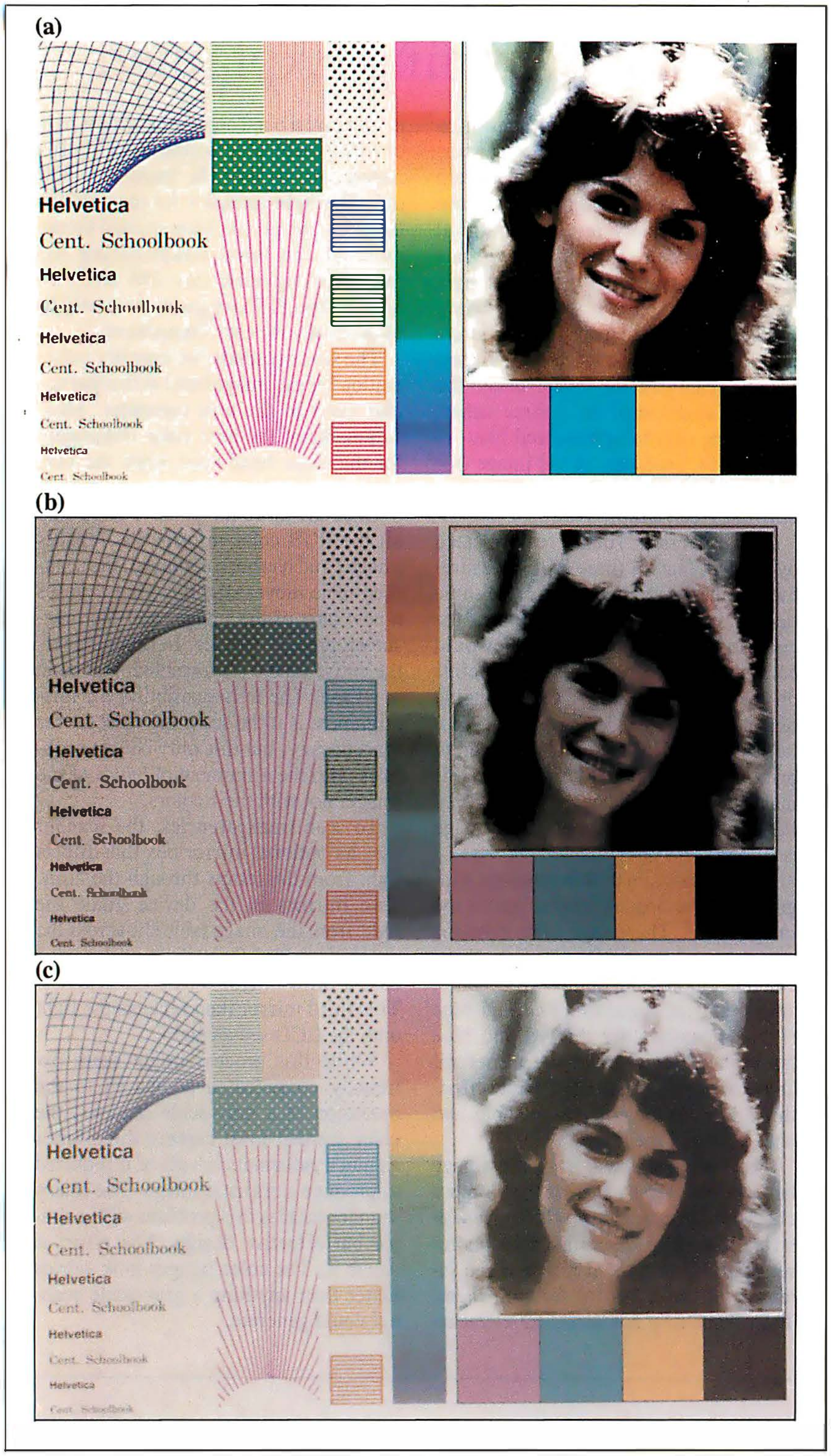


Figure 1: (**a**) *The BYTE color test pattern for scanner quality.* (**b**) *The test pattern scanned at 300 dpi on the Sharp JX-450.* (**c**) *The pattern scanned at 300 dpi on the Howtek Scanmaster. All images shown are actual size. I used LaserPaint Color II with the Sharp JX-450, and MacScan-It with the Howtek Scanmaster. To avoid degrading the image quality, I saved the images as PICT2 files and sent them to a computer graphics firm to make direct color separations. The firm experienced some difficulties with the LaserPaint image, so that image was exported as a TIFF file to Avalon Development's PhotoMac application and saved as a PICT2 file.*

to be scanned—a nice touch that saves RAM and disk space. It also saves the data in a larger variety of formats: SIM (a proprietary format that saves all 24 bits of color information), PICT2, 24-bit TIFF (for use with PageMaker and Ready-Set-Go!), and RIFF (for use with ImageStudio).

MacScan-It is stingy with memory. As it obtains 24-bit image data from the scanner, it spools the data to a temporary file on the hard disk. It uses this 24-bit data, as well as any color corrections you've selected, to paint an 8-bit-deep image on the screen. This makes scanning much slower (it took about 3 minutes to scan and view a legal-size document with MacScan-It versus 1½ minutes for PixelScan), but if you use a 2-megabyte machine, you can make large 300-dpi scans without running out of memory.

You also can make certain color corrections (i.e., auto-white, auto-gray, auto-contrast, and custom gamma corrections) once you've scanned in an image. MacScan-It reads the 24-bit color image data from the temporary file as it applies the corrections. This makes additional scans unnecessary, and all color corrections use the same high-quality image data. MacScan-It is also MultiFinder-compatible, and it does a better job of allowing background processing. The XMODEM download completed successfully while MacScan-It worked on a large document.

Neither PixelScan nor MacScan-It can read files. This is understandable, since the primary goal of these applications is to get images into the computer. But MacScan-It's utility would certainly be enhanced if it could read its own SIM files. This capability would enable you to manipulate the image data later without rescanning the image.

I used the BYTE test pattern to judge the quality of the images I scanned (see figure 1). I tested both packages with a Mac II equipped with a SuperMac Technologies Spectrum/8 video board and 19-inch color monitor; I configured the system alternately with 2 and 5 megabytes of RAM. PixelScan distorted or lost portions of the test images at the high dpi settings. I had to resort to LaserPaint Color II to scan in the test pattern on the Sharp scanner.

When I tried to crop the 300-dpi image, LaserPaint didn't have enough RAM to perform the operation; I had to install an additional 4 megabytes of RAM (for a total of 8 megabytes). As figure 1 shows, the test pattern isn't very

continued

large, so, obviously, software that works with copies of an image in memory isn't going to handle large 300-dpi scans. By contrast, with MacScan-It, I was able to crop the image in preview mode, and it performed the scan without a hitch.

Since the scanning hardware is virtually the same, the quality of the test patterns was nearly identical. The only differences, as evident in the continuous-tone portrait, seem to be in the software itself. When both scanners captured the same image, the quality of the image was the same, but the PixelScan image tended to be darker in tone than the MacScan-It image. MacScan-It lets you manipulate the image colors if good color fidelity is required, but with PixelScan, you'll need a graphics application to touch up the image.

Tough Choice

No matter which package you buy, you're going to end up with a Sharp scanner, so your choice is between the two scanning software packages. Is the Howtek package worth the extra $630? Look at it this way: If you buy the Sharp package, plan on using the money you saved to buy decent scanning software, because PixelScan is inadequate. Even though the Howtek MacScan-It software is preliminary, it does a far better job.

Possible candidates to replace PixelScan are LaserWare's LaserPaint Color II (which drives both the Sharp and Howtek scanners) for $595, SuperMac Software's PixelPaint 2.0, also $595, or Imagenesis's ChromaScan software for $195. Registered owners of Letraset's ImageStudio can obtain a special scanning module from Sharp for free.

If you plan on scanning large images at 300 dpi, you might want to factor in the cost of additional RAM. You'll need at least 5 megabytes (preferably 8) to work comfortably with either scanning package (a 4-megabyte RAM-expansion kit from Apple costs $2300).

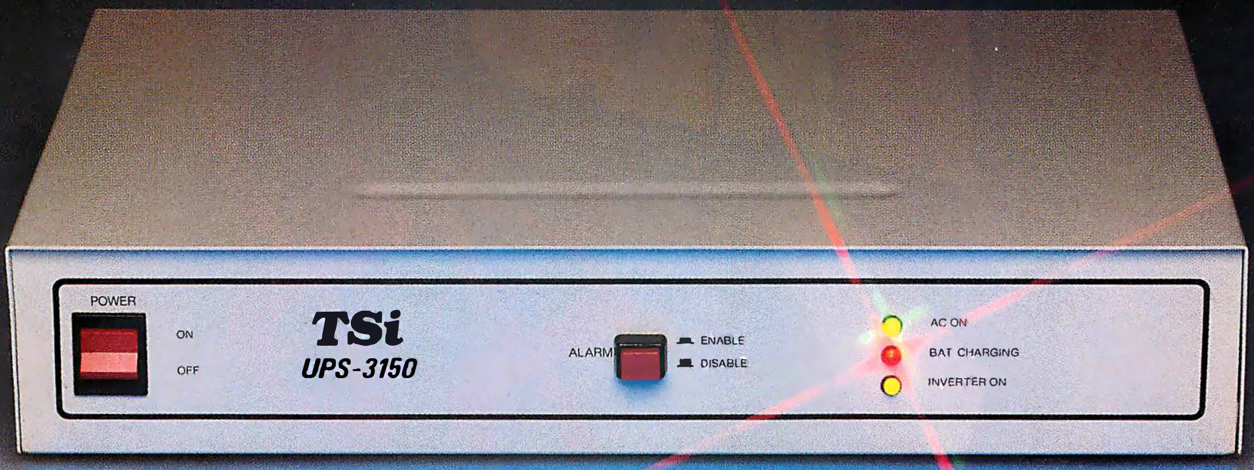
But in most cases, MacScan-It will let you get by with less memory. First, MacScan-It lets you crop the image area before you perform the scan. You capture only the part of the image you need, not everything that fits within a fixed sheet size. This saves on RAM and disk space and on the cost of a color paint package to crop the image. Second, since MacScan-It spools image data to disk instead of holding it in memory, you can make large, high-resolution scans in 2 megabytes of RAM.

The Sharp scanning unit is an impressive piece of hardware that lets you digitize color images and save them on your computer in a matter of minutes. The results are crisp and snappy. More important, these relatively low-cost color scanners open up new possibilities in the areas of art, scientific, and multimedia applications. For example, a doctor might scan x-rays in gray scale and then use false colors to help pinpoint a tumor or blood clot. Research geologists would digitize satellite photos and enhance their contrast to bring out specific details hidden in the image.

Now that the technology to import color images quickly and easily is available at a reasonable cost, the Mac II is set to fulfill its promise as an image-processing engine. And the scanner's ability to collect 24-bit data makes it ready for Apple's 32-bit Color QuickDraw when it arrives. ■

Tom Thompson is a BYTE senior technical editor at large. He can be reached on BIX as "tom_thompson."

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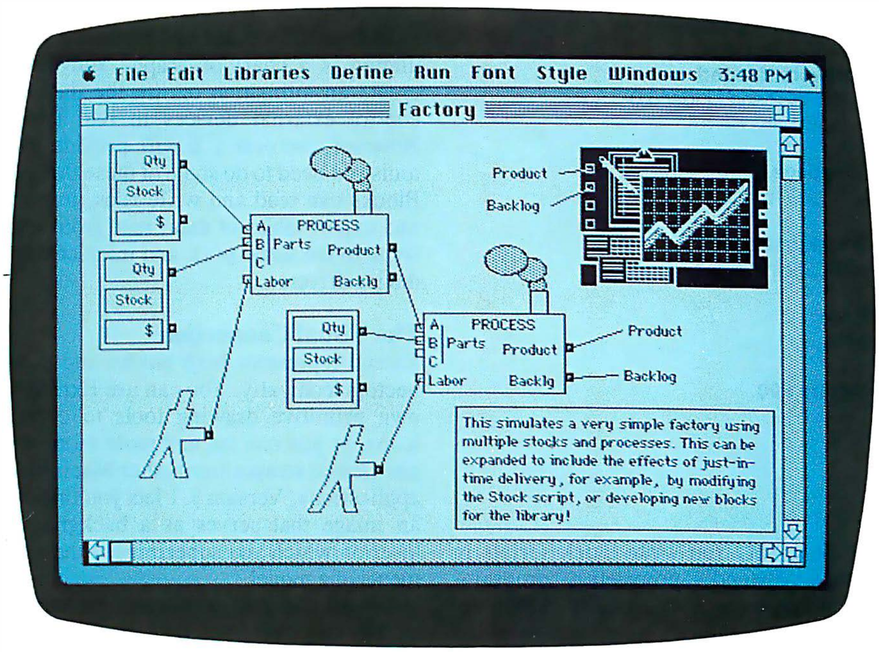
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Extend

A general-purpose simulation toolkit for the Mac

Ray Valdés



By simulating real-world behavior in software, computers help us to understand the world outside of the machine. This simulation entails modeling the flow of matter, energy, or information through a real-world system. Extend 1.05 from Imagine That! is a simulation toolkit for the Macintosh. Like the traditional packages Simscript and General Purpose Simulation System, Extend reduces the behavior of a system that it models to a graph or a chart. Unlike its mainframe predecessors, Extend provides a slick object-oriented environment within which you construct simulations—in effect, a tinker-toy set that you use to graphically define and interconnect processes and flows. I used it to explore the dynamics of a commuter highway; it's equally well suited to problems in biology, business, economics, medicine, or physics.

I ran Extend on a Mac SE with 4 megabytes of RAM and a 40-megabyte hard disk drive. I tried the package with a *Radius* 68020 accelerator card and with the standard 68000 CPU. The accelerator isn't required, but I recommend one for serious work. I began with version 1.05 and later received a beta copy of version 1.1, which will ship by the time you read this.

The package comprises two 800K-byte floppy disks and a 200-page manual. Earlier versions of Extend (like other Mac applications) shipped with a copy of Apple's System and Finder. The current version assumes you already have Apple's software and fills the disks with additional example files. That's useful, because Extend is complex. The cookbook examples do a good job of showing you how to construct particular kinds of simulations in Extend.

Extend 1.05 occupies 376K bytes of RAM; you need 442K bytes of RAM for version 1.1. There are two types of associated files: stored models, or worksheets, and libraries of model elements, or blocks. The sample models provided with the package range in size from 20K bytes to 50K bytes. A typical library might contain five to 10 blocks and occupy 100K bytes. So, although it's better to have a hard disk drive, you can fit the program, one or two libraries, and a few worksheets on a dual floppy disk drive–based Mac system.

Creating a Simulation

In Extend, as in other simulation programs, a system is a network of entities that can receive inputs, mathematically transform them, and produce outputs. An entity can be a pure producer, a transformer that both consumes and produces, or a pure consumer. My traffic model comprises four blocks. One, representing a suburb, produces cars. Another, representing a city, consumes those cars. A third represents the highway connecting the two. The fourth plots the flow of traffic through the system.

You can attach as many as 128 I/O ports, or connectors, to a block. In my model, the suburb has a single output connector, the city has a single input connector, and the highway has one of each. What flows through these ports in a simulation model is data in the form of integers, floating-point numbers, or, in the case of version 1.1, arrays. The numbers can represent anything; in the traffic model, they represent cars.

In Extend, the behavior of each block is defined in a stored program called a

continued

Extend 1.05

Type
Simulation modeling toolkit

Company
Imagine That!
7109 Via Carmela
San Jose, CA 95139
(408) 365-0305

Format
Two 800K-byte floppy disks

Hardware Needed
Mac Plus, SE, or II with 1 megabyte of RAM and two floppy disk drives (a hard disk drive is recommended)

Software Needed
System 4.2 and Finder 6.0 or higher

Language
C

Documentation
200-page manual

Price
$495

Inquiry 890.

block script. You write block scripts in ModL, Extend's proprietary programming language. Syntactically, ModL resembles C, though its object-oriented style (e.g., the way you write handlers for events) reminds me of HyperTalk and Smalltalk. Because Extend contains a script editor, you can develop, test, and refine ModL code within the program.

Once you've configured a model, you run it for a specified length of time. At intervals, Extend sends a simulate message to each block in the system. Blocks can respond to that message by retrieving data from input connectors, processing the input data or simply generating new data, and placing data on output connectors. If you've asked for a graphical or tabular display of the results, as is usually the case, Extend will present one and update it with each tick of the simulation's clock.

For example, I set up my traffic simulation to run for one 24-hour day at 1-hour intervals. Every hour, the suburb produces a batch of cars. The script associated with the suburb governs the number of cars produced; it arranges for peak flows between 6 a.m. and 9 a.m., around noon, and in the early evening. At the same time, the script for the highway reads and tries to process that batch of cars. The highway can handle a certain number of cars per hour. Excess traffic accumulates on the suburb's output connector—metaphorically, a backlog waiting to be admitted to the highway during the next cycle. For the city's script, I duplicated the logic I used for the highway. The city accepts cars from the highway at a certain rate; excess traffic accumulates as backlog. The script associated with the plotter block reads data that describes the flow of traffic in the city and, using Extend's built-in plotting function, graphically displays those numbers.

In Extend 1.05, the end result of a simulation is a chart or graph. You can't create an animation or use the data to control external devices in real time. However, version 1.1 will provide the tools you need to do some of these things. Blocks can read and write files, import and export tables of data, read from and write to the serial port, and interact with device drivers.

The Visual Connection

Extend represents both blocks and connectors iconically. You can use Extend's own primitive drawing tools to create icons, or you can cut and paste more sophisticated images from other Macintosh applications. Version 1.1 lets you import an image that serves as a background layer on which you superimpose the elements of a model.

Blocks can poll connectors for input, or they can query you for input directly. The latter method provides a powerful mechanism for parameterizing models. With Extend's dialog-box editor, you can create fielded forms. Values entered into those fields are available directly to ModL. Moreover, Extend automatically adds a handler for each field to the associated script. These handlers provide hooks to which you can attach code that validates or transforms input.

In my traffic model, I set the parameters for the capacity of the highway. Running repeated simulations with different values for highway capacity, I found a threshold value—at about half the peak outflow of cars from the suburb—beyond which chaos ensued. Gridlock set in by midmorning and did not clear until well past 9 p.m.

I could have elaborated on the traffic model by creating additional instances of the suburb and highway blocks and connecting them in different configurations to approach a more realistic metropolitan situation. That's easy in Extend, since blocks and connectors behave like objects in a drawing program. You can select, drag, and duplicate the elements of a model. Because Extend knows that connectors mean something, it maintains the relationship between blocks and connectors when blocks move.

To open a block's dialog box, you double-click on its icon. That's useful, but it points up some limitations inherent in the iconic representation of blocks. First, unless you attach to an icon some visual cue that alerts you to the presence of a dialog box, there's no way to know which blocks in a worksheet might contain useful dialog boxes. Second, because block icons are static images, they can't reflect the status of user-modifiable variables. For example, if I had set up a dialog letting me choose between a two-lane and a four-lane highway, there wouldn't have been any way to get the highway's icon to reflect that.

But that's a minor gripe. Extend implements a flexible and highly interactive environment. You can begin with a simple model (e.g., a few blocks, each with a basic script) and then work incrementally toward the desired level of realism by enhancing scripts, adding user-modifiable parameters in dialog boxes, and changing the configuration of blocks and connectors.

A worksheet has a single main window that shows the configuration of blocks and interconnections. When you press Option and double-click on a block, its editing window or structure window appears. The structure window contains five tiled panes. The largest contains Extend's text editor, which acts a lot like the Lightspeed C editor. The drawing pane, where you construct icons, provides a subset of the MacDraw tools. The tool palette fits uncomfortably into the space provided for it, and I found myself wishing for a tear-off menu instead. The remaining panes contain an editor for creating help texts, a list of the current block's input and output connectors, and a list of the messages that the block can handle. When you invoke the dialog-box editor, it appears in a new pane that overlays the others.

Extend stores the script, dialog box, icon, and help text associated with a model outside the worksheet, in separate library files. The advantage is, of course, that you can reuse parts of the models. However, the disadvantage is that the worksheet file refers to other files that you must transfer when moving to another disk or system. Extend does provide a library manager, with which you can move blocks into and out of libraries.

Table 1: *ModL functions by category.*

Trigonometric	Sine, cosine, tangent, arccosine, arctangent, cosineH, sineH, tangentH
Numeric	Ceiling, floor, exponent, fast Fourier transform, integrate Euler, integrate trapezoidal, integer absolute value, real absolute value, log base e, log base 10, real modulo, square root, mathematical gamma function*
Matrix*	Conjugate, determinant, Eigen value, identity matrix, complex identity, dot product, complex dot product, LU decomposition, complex LU decomposition, invert, complex invert, matrix product, complex matrix product, scalar product, complex scalar product, vector product, complex vector product, tensor product, complex tensor product, transpose, complex transpose, polynomial roots
Statistical	Gaussian distribution, random distribution, random real distribution, arithmetic mean, standard deviation of sample, standard deviation of population, binomial distribution*, exponential distribution*, gamma distribution*, lognormal distribution*, geometric distribution*, Poisson distribution*
Queue manipulation	Initialize queue, get and put from queue front, get and put from queue rear, length of queue, peek at nth member*, get nth member*, set nth member*
Dynamic arrays	Make dynamic array, get array dimension, dispose dynamic array
Dialog box	User error dialog box, user prompt dialog box, beep, help dialog box, open block's dialog box*, close dialog box*, speak a string using Macintalk*
Time and date	Get current time and date
Financial	Calculate present value, future value, number of periods, payment, and interest rate
Plotting	Install axis, get axis, get signal value, plot new point, remove signal, retime axis, show plot, dispose plot, autoscale x*, autoscale y*, plot signal format*, make scatter plot*, plot new scatter point*
Array passing*	Pass array to connector or global variable, get passed array
Bit functions*	Bit set, bit clear, bit and, bit or, Bit xor, bit not, bit shift, bit test
Complex math*	Add complex numbers, divide complex numbers, multiply complex numbers, subtract complex numbers
Device driver*	Open driver, close driver, read from driver, write to driver, send control code, get device status, terminate operation
File I/O*	Open file, read from file, get delimiter, check end of file, close file, create new file, write to file, rewind file
Import/export*	Import from path name into array, export from array to path name
Serial I/O*	Configure serial port, read from serial port, write to serial port
String*	Length of string, get substring, find substring, replace substring, convert from integer to ASCII
Timing*	Get current tick count, wait for N ticks
Worksheet inquiry*	Get number of blocks in worksheet, get name of block, get number of block

*Version 1.1 enhancements.

Modeling with ModL

Because it looks like C, ModL is easy to learn. However, ModL is insensitive to case, uses two asterisks for comments, and supports the keyword `real`, as opposed to C's `float`, and it doesn't support the ++ operator. It annoyed me a bit, but it might not bother you.

Table 1 lists some of ModL's built-in functions. You can augment that list with functions that you write in ModL. Unfortunately, the scripts for these are not separable from the block script in which they appear, so you can't reuse them as conveniently as you can entire blocks. A library manager for functions would be a welcome addition; so would a debugger. ModL doesn't support pointers, and it won't let you touch memory directly, so you can't get into too much trouble. You can usually debug a script by examining its output. But whenever I find myself inserting print statements into code, which is what happened while experimenting with ModL, I yearn for a source-level debugger.

Blocks can't receive and act on user-defined messages, as objects in HyperTalk scripts can, and they can't inherit behavior as Smalltalk objects do. Such features aren't necessary for the kinds of things most people want to do with ModL, but they would make life easier for model writers.

Extend performs well for small to medium-size models with five to 10 blocks. There's a noticeable degradation of performance when models become large

continued

and contain dozens of blocks, which made me appreciate my 68020 accelerator. But you have to keep things in perspective. Extend is a drawing program, a programming language compiler, a plotting package, a resource editor, and a mathematical function library. Extend's drawing functions are probably slower than those in MacDraw II. Extend's compiler probably compiles more slowly than Lightspeed C. There are undoubtedly faster plotting programs and resource editors. But there isn't another Macintosh application that better integrates the tasks required to construct simulation models.

The steepness of Extend's learning curve varies with a user's level of experience with simulation, programming, and the Macintosh. Accordingly, it might take you weeks to become proficient, or it might take you just a few days. Once you have mastered the necessary skills, though, you can create nontrivial working simulations in very short order.

Managing Complexity

To stretch the capabilities of the program, I used Extend's cut-and-paste facility to expand my traffic model. With 50 blocks in the model, performance slowed noticeably, but it was still acceptable. What limits Extend isn't performance but comprehensibility. A large Extend model suffers from the same problems as a large spreadsheet. Because you can't hierarchically decompose structures, things can get confusing. A single element in a model can't represent a subsystem, and it can't link to a submodel in a separate worksheet. Everything in a model exists on a single level, such as a set of blocks situated in a large two-dimensional workspace.

Because of this limitation, Extend is definitely not suited for the simulation of systems with hundreds or thousands of components. The ability to structure models hierarchically would be a big improvement.

Although Extend generally takes advantage of the Macintosh interface, there are a few anomalies. For example, when the cursor traverses a worksheet, it changes according to the object you point to. If you point to a block, the cursor represents a hand, indicating that you can drag the block to another position. If you point to some text, the cursor changes to a text caret, which means you can edit the text. Macintosh programs don't usually handle modal changes that way—though it's a convenient and arguably better method. Instead, they provide a palette of tools (e.g., to enter text mode, you select the text tool from the palette).

Extend is to professional simulation work what desktop publishing programs are to the graphic arts: It's a personal computer program suitable for small- and medium-scale work. As in desktop publishing, there are high-end jobs for which PC-based programs are not appropriate. This does not mean the program should not be taken seriously. If you already do simulation modeling, it will significantly improve your productivity. And if you are new to simulation and would like to model a problem in business, science, or engineering, you should take a close look at Extend. ■

Ray Valdés is president and founder of Sapphire Software, a technology consulting firm in San Francisco, California, that specializes in the design and development of graphics software. He can be reached on BIX c/o "editors."

Mac Desktop Presentation Software

Three graphics packages that give you the power of persuasion

Lawrence Stevens

Unless you're one of the lucky few who can keep an audience at the edge of its seat with your rhetorical ability (or your good looks), you probably depend on flip charts, transparencies, and slide shows to complement your verbal presentations. And unless you're a whiz with stick-on letters, your organization's art department or outside sources probably help you create those presentations. But you could use your Macintosh.

Three programs I looked at, StandOut! 1.0, PowerPoint 2.00A, and Cricket Presents 1.0, let you do just that on a Mac Plus or larger system. They combine text and graphics capability along with other features that help you organize and display your presentations.

One of the most interesting features of these programs is their ability to display all the presentation's frames in reduced form on the screen at once, much like a light table displays a set of slides. (A "frame" can be an individual slide, a flip-chart page, or a transparency.) This lets you get an overview of the entire presentation, and you can see how both the ideas and design of each frame fit with adjacent frames. You can easily rearrange frames to make the presentation flow nicely.

Another interesting aspect of these programs is that they automatically create handout and note pages for each presentation. A handout page contains two to eight reduced frames that you can distribute to your audience. The note page has one reduced image of each frame per page, along with a space for the speaker's notes.

Of course, one of the biggest advantages of these desktop presentation programs is that they let you use the Mac itself as a display device. In this mode, software tools such as the menu bar and scroll bars disappear, and the presentation's frames are displayed consecutively as they would be in a slide show. The frames change each time you click the mouse button, or you can specify how many seconds each frame will appear on the screen before it is replaced with the next one.

You can create a set of transparencies with a laser printer or have your printing house create slides or transparencies from your printed output. Cricket Presents and PowerPoint also provide a service for turning your frames into 35mm slides. You send files by modem or mail, and the slides are produced within 24 hours.

Text Handling

Most presentations are primarily made up of text, and all three programs have features that let you easily enter text and format the style and size of the characters. But PowerPoint and StandOut! provide more options for sprucing up text with borders and background patterns and for joining text to other elements of the frame. Once you create text in these packages, it is treated like any graphics element; you can fill it in, or you can give it a border of any pen size, pattern, or color. Cricket Presents provides the least graphical control of text in that it does not let you create any graphics elements, such as borders, directly around text.

In PowerPoint, you can also attach text to any object, such as a square or a circle, by first creating the object with a drawing tool and then typing the text you wish. The text will appear within the object with the alignment, font, style, and type that you choose. You can opt to have any overflow text run outside of the object, or you can have the object resize itself to accommodate the length of the text. Of course, all three programs let you place text inside a graphics element by first using a graphics tool, then using a text tool, and finally grouping the graphics and text. But PowerPoint's process is simpler.

Besides its text tool, PowerPoint has a labeler tool that lets you enter text without creating a text box. Text boxes, which are used by all three programs but are optional with PowerPoint, define the area where the text will appear. Since the labeler tool does not define any area, it's much quicker to enter text that does not have to be confined to a specific section of the frame.

While PowerPoint is strongest in combining text with graphics, StandOut! provides the most control over typographical elements. All three programs let you specify normal typing attributes such as superscript, subscript, and tabs. But in StandOut!, you can perform typesetting-like functions such as shifting characters up or down any number of points, kerning, and specifying line spacing or space between words or letters.

Both StandOut! and PowerPoint let you create style sheets in which you can save complicated text formats and then apply them with a few keystrokes. PowerPoint's style sheets are slightly easier to use because they appear in submenus, and you can apply them with option/letter commands. On the other hand, style sheets in StandOut! are listed in a separate window. StandOut! also includes a glossary function. Both programs have find-and-replace functions as well as spelling checkers.

Cricket Presents and StandOut! can also align or center objects on the page. You can center or align objects vertically or horizontally by their top, bottom, or left or right side.

continued

	StandOut! 1.0	PowerPoint 2.00A	Cricket Presents 1.0
Type	Graphics package	Graphics package	Graphics package
Company	Letraset USA 40 Eisenhower Dr. Paramus, NJ 07653 (201) 845-6100	Microsoft Corp. 16011 Northeast 36th Way P.O. Box 97017 Redmond, WA 98073 (206) 882-8080	Cricket Software 40 Valley Stream Pkwy. Malvern, PA 19355 (215) 251-9890
Format	Three 800K-byte floppy disks	Three 800K-byte floppy disks	Six 800K-byte floppy disks
Hardware Needed	Mac Plus, SE, or II (a Mac II with 2 megabytes of RAM and a color monitor is recommended)	Mac Plus	Mac Plus
Software Needed	Any version of System	System 4.1 or higher	Any version of System
Language	C	C	C
Documentation	265-page manual; 36-page design guide; 26-page tutorial; 16-page quick reference guide	360-page manual; 5-page Using PowerPoint Genigraphics Presentation Services; 16-page SmartScrap manual; 28-page quick reference guide; 60-page Using PowerPoint Templates	244-page manual; 74-page reference manual; 16-page Using Templates and Color Palettes; 9-page release notes; 20-page autographix manual; 54-page Acta user's manual
Price	$295	$395	$495
	Inquiry 886.	**Inquiry 887.**	**Inquiry 888.**

StandOut! is the only one of the three packages that allows runaround text. If you specify runaround text for any graphics element, the text that overlaps the element will also surround it. You can even specify how close the text should come to the object.

Charts and Graphics

All three programs let you cut and paste charts created by other programs. But StandOut! and Cricket Presents can also generate charts. Both programs have the full range of charts: bar, column, scatter, area, line, and pie. And each program gives you wide latitude in formatting the elements of the chart. You can change the order of the data and specify the size of lines and fill patterns. You can also add and remove labels and switch from one type of a chart to another.

You enter the data for these charts into a data sheet that looks like a spreadsheet. But unlike a spreadsheet, the data sheet does not accept formulas, so you have to do any calculations manually.

StandOut! lets you import data directly from an Excel worksheet into its chart data sheet, so you can have Excel do the calculations for you. The Excel data must be in a specific format (i.e., alphanumeric data and numeric data in specific columns), but the format follows a spreadsheet's typical arrangement anyway.

You can create tables of data in any of these programs using tabs along with lines and boxes created with the drawing tools. But Cricket Presents makes this task easier by providing a specific Table tool where you enter data in boxes and then format the table any way you want.

All three programs also have a drawing capability, but Cricket Presents is the most fully featured. It has a total of 10 drawing tools, including line, arc, rectangle, rounded rectangle, polygon, and freehand. By contrast, StandOut! has eight and PowerPoint has only four. Neither StandOut! nor PowerPoint provide tools for rounded rectangles and freehand drawing. And PowerPoint is particularly limited in that you can't create such standard shapes as diamonds, parallelograms, and arcs.

Imported Graphics

You can create an entire presentation with only the tools contained in the presentation software. But you may find that you need to import text or complicated images from other applications. All three programs let you import graphics images directly from most Mac drawing files, such as PICT, PICT II, Encapsulated PostScript Format, and MacPaint.

Just in case your graphics files are very large, which is often the case with 256-color files, Cricket Presents has a way to eliminate the memory and speed problems that often result. Any imported files that are over 32K bytes are not really transferred into a Cricket Presents frame. Instead, they remain on the disk, hot-linked to the appropriate frame. When working on the frames, you can see a symbol on the screen that represents the image. You can resize and move the symbol and then get a description of the image by double-clicking on the symbol. When you run a slide show on the Mac or print the file, the program retrieves the image from the disk.

To use images created with software that can't be directly imported, you must cut and paste from one application to another. If you don't have MultiFinder or Switcher (or the large amount of memory required to run them), the only reasonable way to do this is through the Scrapbook. PowerPoint comes bundled with SmartScrap, an improved Scrapbook that gives you a table of contents and lets you scroll to see all the image, copy and paste selected parts of the image, and have multiple Scrapbook files.

PowerPoint lets you import files directly from More or ThinkTank, two powerful stand-alone outliners for the Mac. When you import a file from either of these programs, PowerPoint automatically creates a new presentation from the outline. The first frame of the presentation contains a list of the main topics in the outline. Each frame after that con-

tains one main topic and all the subtopics indented in the same format as the text in the outline. You then can use all the PowerPoint tools to modify the presentation.

Cricket Presents comes bundled with Acta, a powerful desk accessory outliner. Since it is a DA, it can appear on your screen along with Cricket Presents so that you can easily cut and paste from one to the other.

Elements of Design

After creating a number of presentations, you'll probably find that many of your frames use the same design elements. You can use templates to save your commonly used forms, including the text style, color, layout of objects, and background elements such as logos. You may have some templates that contain the complete frame design, while others may contain formats for only part of a frame, such as placement of text or graphics, background color, or layout of a table. You can either add elements to these partial templates or combine two or more templates to create a complete frame.

While the most useful templates will be those you create yourself, all three programs come with templates to get you started. PowerPoint has over 100, and Cricket Presents and StandOut! have about 50 each.

Each of the programs organizes templates in different ways. The method used by Cricket Presents is the most convenient. It lets you view all templates on your disk through a window that displays the template name, a 2-inch square image of the template, and any notes you may want to make about it. When you find a template you want to use, a simple mouse-click automatically pastes it into the frame you are working on. PowerPoint and StandOut! save templates in separate files. To use these templates, you have to open the file, view the templates, choose the one you want, and then copy and paste it into your frame.

All three programs can generate presentations in either monochrome or color. Obviously, the best machine for creating color output is a color Mac II. But even if you have a Mac Plus or SE, you can use the eight colors available to (but not visible on) those computers to create acceptable color presentations. I found eight colors adequate for just about any presentation.

PowerPoint also comes with color schemes. These contain eight colors that are chosen for their aesthetic compatibility. When you switch from one color scheme to another, the colors of all the

If you just want to copy and paste text or graphics from other applications into frames, any of these programs will do.

elements, background, text boxes, and so on will also change. In that way, you can view your presentation in different colors while being sure that all the colors will be compatible.

The Big Picture

If all you want to do is copy and paste text or graphics from other applications into frames for your presentation, any of these programs will do. But to do more than that, each program has strengths that optimize it for different types of work.

For creating graphics and charts, Cricket Presents is the best, with StandOut! a close second. Both programs have a full range of drawing tools, but the rhomboid and polygon drawing tools, both of which are unique in Cricket Presents, may come in handy. Similarly, if you need stacked bar, line, or area charts, Cricket Presents is your only choice.

Both PowerPoint and StandOut! have strong text resources. But PowerPoint, with three text tools rather than one, makes text entry easier. PowerPoint's ability to let you enter text without first having to create a text block can make labeling objects and placing floating text around a frame very easy. Both PowerPoint and StandOut! also have spelling checkers, which can save you from embarrassing moments.

If you find yourself needing the more precise text measurements normally found in page layout programs, StandOut! is a better choice. It gives you more control over such things as line and letter spacing, and it also has style sheets and glossaries to speed up input. ■

Lawrence Stevens is a freelance writer based in Springfield, Massachusetts, who prepares presentations for Holyoke Community College. You can reach him on BIX c/o "editors."

CASE

CASE, or computer-aided software engineering, is a *tool* for programmers, analysts, and systems engineers, as well as for business planners and executives at all levels and for businesses of all sizes, shapes, and structures. To quote Carma McClure, "CASE is software automation." It provides software tools to help corporate planners plan, and to document their work; to support systems analysts in analyzing and designing systems, and to document those tasks; and to take some of the drudgery out of programming while documenting it.

Sounds better than sliced bread, doesn't it? If it is, why haven't you heard more about it from BYTE? Because until recently, CASE tools cost in the five- and six-figure price range and only ran on mainframes. Now, the majority of them run on microcomputers, and many are available for less than $1000.

So, this month we introduce CASE, BYTE-style. The In Depth section has among its authors some of the top people in the field. We begin with "The CASE Philosophy" by Michael Lucas Gibson. This article introduces the concepts and capabilities of CASE and explains what the different elements of CASE are and what they are for. CASE itself is modular, and you may find that some parts of it fit your environment while other parts do not.

You can't talk about CASE without discussing methodology. In a field based on structured methods, there are an amazing number of different approaches to that structure. In the article "Methodology: The Experts Speak," some of the gurus of various methodologies present the approaches for which they are known. This article contains "The Warnier/Orr Approach" by Ken Orr, "The Gane/Sarson Approach" by Chris Gane, "The Yourdon Approach" by Edward Yourdon, "The Entity-Relationship Approach" by Peter P. Chen, and "The Structured Design Approach" by Larry L. Constantine.

In addition, "The CASE Experience" by the renowned CASE authority Carma McClure discusses some of the various CASE tools, toolkits, and workbenches available today for microcomputers—what they do, what CASE functions they deal with, and how they fit into the whole picture. She also includes three CASE success stories. Finally, she provides our resource guide this month, "A CASE Workshop," with a list of contact information for the products discussed in her article.

—Jane Morrill Tazelaar
Senior Technical Editor, In Depth

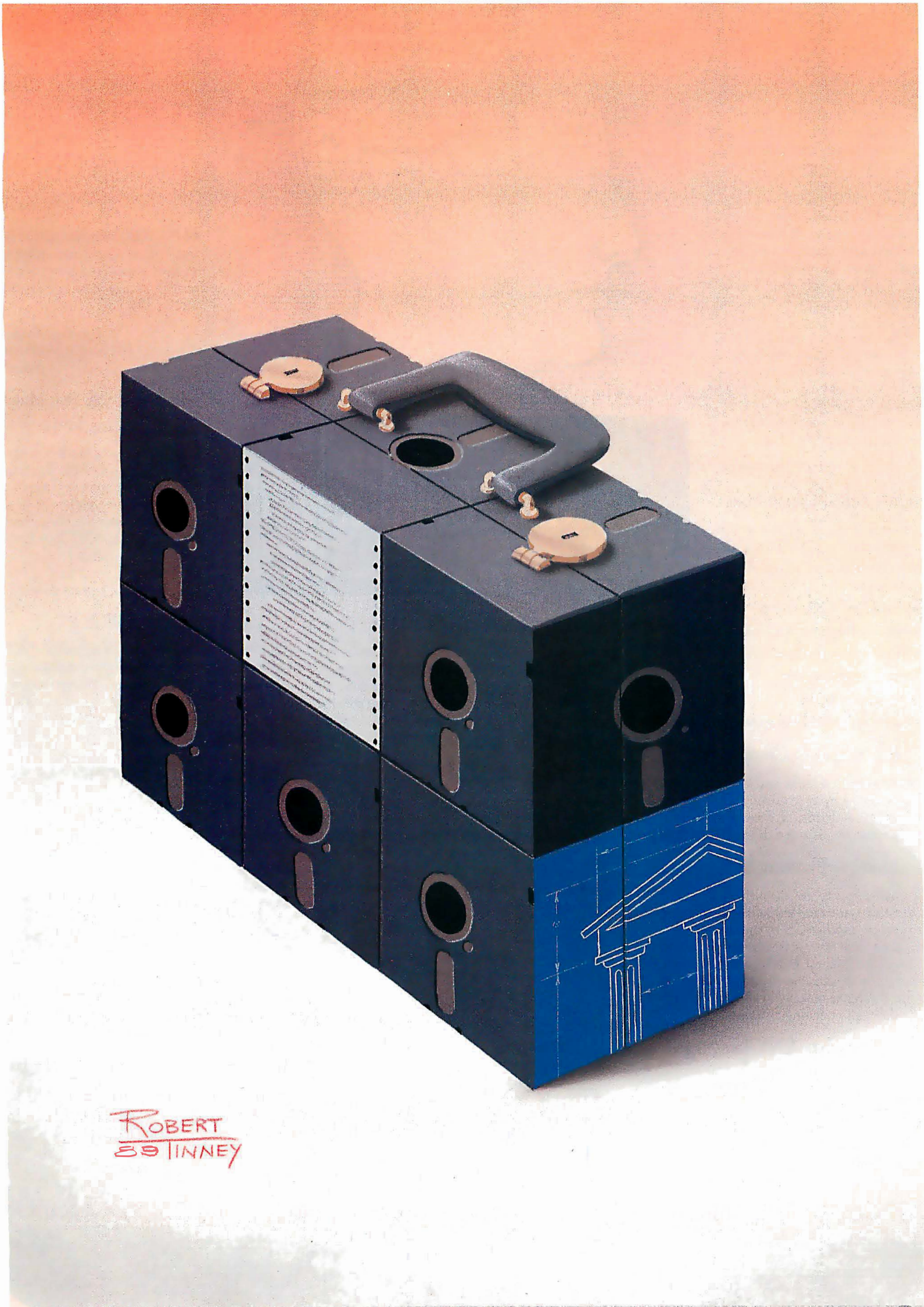


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The CASE Philosophy

The whole picture involves integrating corporate plans, systems design, and systems development into one system

Michael Lucas Gibson



Computer-aided software engineering (CASE) represents a comprehensive philosophy for modeling businesses, their activities, and information-systems development. The CASE philosophy involves using the computer as a development tool to build models that describe the business, the business environment, and corporate planning, and to document computer-systems development from planning through implementation.

Components of CASE

Breaking CASE down into component parts makes it easier to understand. However, there is disagreement about whether upper CASE, middle CASE, and lower CASE have any reality. Many CASE vendors and gurus think that this functional separation is just a journalistic device. Perhaps it is, but it is also convenient and provides a familiar frame of reference for discussion.

With that in mind, I will use the terms here to refer to the computer-aided components supporting the various CASE functions. I make no claims about my definitions or even acceptance of these terms elsewhere. Upper CASE, often called computer-aided planning, will refer to a computer-aided component that supports corporate planning. Middle CASE will refer to a component that supports systems analysis and design. Lower CASE will refer to a component that supports systems development.

Another confusion in the CASE arena is that there are no standards. Each vendor includes and omits whatever it wishes based on its own criteria. And each vendor would like its implementation to be accepted as the standard. Such organizations as the Software Engineering Institute at Carnegie-Mellon University and the Center for Advanced Information Management at Auburn University have emerged to provide CASE guidance. A research goal of the CAIM is to arrive at standards for CASE. (See the text box "The Center" on page 211.)

The complete picture of the CASE philosophy prescribes that specifications for corporate plans, systems design, and systems development become fully integrated. This occurs by sharing specifications for the three functions of corporate planning, systems analysis and design, and systems development across CASE components.

In a fully integrated CASE environment, computer systems originate in the corporate-planning function (see figure 1). Corporate planners create computer specifications for developing functional corporate plans using upper CASE, specifications that embody planning requirements for the company's fundamental activities.

continued

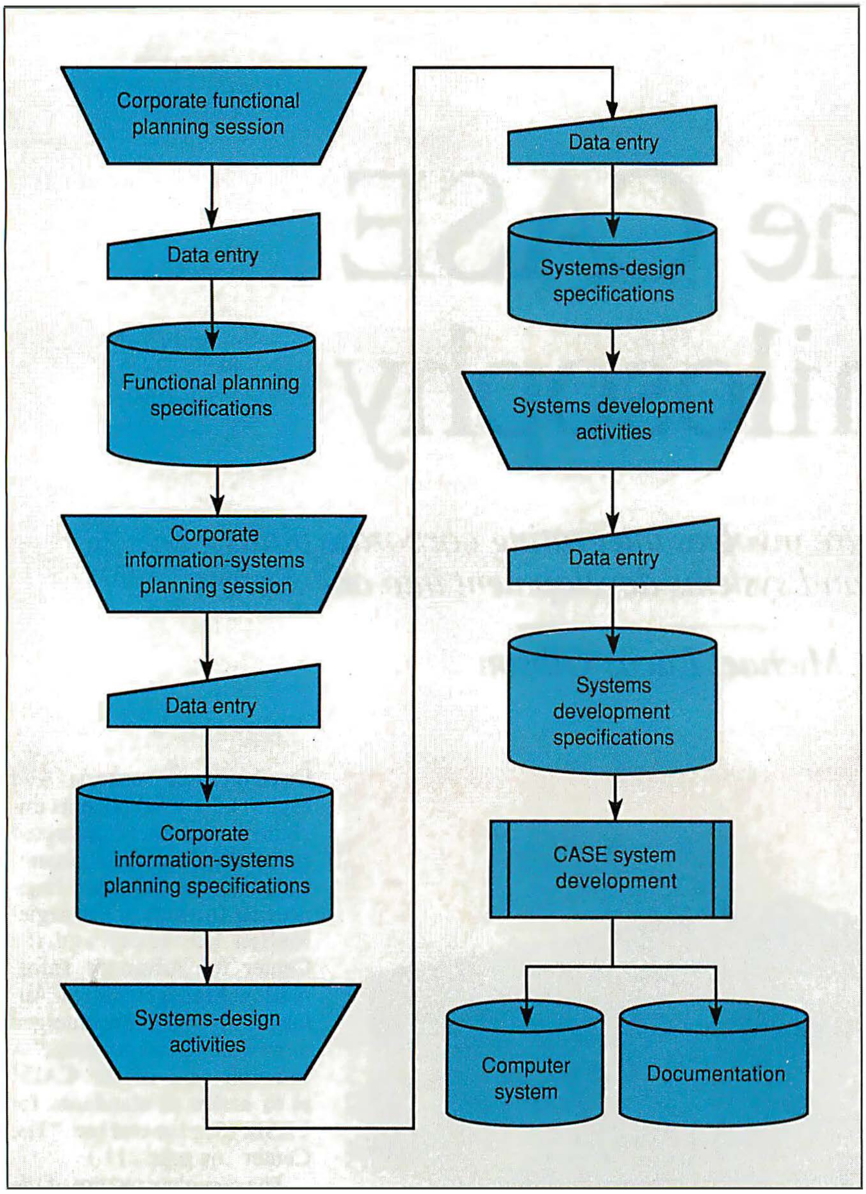


Figure 1: *A fully integrated CASE environment: from corporate planning through systems analysis and design to program code and documentation.*

These functional corporate plans are input to computer specifications for corporate information-systems planning. Corporate planners enhance these specifications relative to intrinsic information-systems attributes. Then the corporate-planning specifications are input to design specifications for computer systems. Systems analysts enhance these design specifications using middle CASE.

The design specifications are then input to the development specifications for computer systems and end-user documentation. Systems developers enhance the development specifications to make them more comprehensive using lower CASE. Lower CASE systems use these development specifications to generate the application system and accompanying end-user documentation. Thus, the computer is used as a development tool to integrate planning with the design and development of computer systems.

Most of the understanding of how a business functions, and how information services that functioning, resides in the minds of a relatively small group. Over the years, companies have attempted to build models to document these things. These models were created to symbolize the knowledge of key people in an effort to better secure and more comprehensively use their accumulated knowledge.

A number of methodologies have been devised for model building. These methodologies usually consist of a combination of diagramming techniques and text descriptions. Diagrams express pictorial images of the business's activities and of how it uses information to support these activities. Diagrams also graphically describe the attributes used in systems design and development.

The diagramming techniques use icons to represent various components of the business: personnel, resources, data, and so on. Each icon on representative diagrams usually has a text description explaining its purpose, its responsibilities relative to business activities and information support, its relationship to other icons on the diagrams, and so forth. The text descriptions include enough information to sufficiently describe the real-world object that the icons represent.

Model-building methodologies provide some guidance for building models that represent corporate activities and systems development. However, business models require frequent modifications as business changes. If the models are constructed by hand, these changes require a great deal of effort. As a result, elaborately constructed manual models frequently become outdated. In addition, if you spend a lot of effort building a manual model, you may not be inclined to spend additional effort to change it. Model building constructs a symbolic representation of various facets of the business for review and subsequent improvement prior to actual commitment. Thus, change is inherent in model building and should be made as easy as possible.

Some vendors have developed software systems that automate many of the methodologies (see references 1 through 6) used in model building. These systems implement a large portion of the CASE philosophy by providing diagramming methodologies accompanied by text descriptions. Many CASE systems execute on desktop computers with the more graphically oriented systems requiring a mouse. You issue commands through menu or function-key selection using a portion of the screen to enter appropriate model specifications.

Within the more graphical methodologies automated through CASE systems, some icons have a variety of purposes. The text description behind the icons describes what the icons symbolize within the facet of the business currently being modeled.

You enter the text descriptions into a portion of the CASE system known as the *dictionary* (some CASE systems have

embedded DBMSes serving this function). The dictionary contains preformatted screens associated with different graphical icons. Entries on these screens supply important information concerning the aspect of the business the icons symbolize. The dictionary also keeps a directory indicating the relationships between specific diagrams, icons, and text descriptions.

Upper CASE

Corporate managers spend much of their time trying to understand the company and create plans for its activities. Corporate plans prescribe goals, generate strategies for achieving these goals, establish policies to focus the company's operations toward these goals, and establish standards for acceptable levels of performance within these operations.

Upper CASE uses software to describe the company and its plans. It uses graphical diagrams to decompose the company's important aspects and describe them. Some of these aspects are the various departments and their functions and processes. Others include the goals, objectives, responsibilities, resources, problems, and so on, of the company and its various departments. Decomposing aspects of a business provides graphical and textual information to help you gain a clearer understanding of the company and the conditions facing it.

You can use these descriptions to create strategic plans. The planning specifications represent the resources and task completions needed to accomplish corporate plans. The planning methodology provides the structure into which you enter these planning attributes. The structure has built-in functionality for indicating the relationships between the components of the plan and the accoutrements they require. For different plans, the structure of the company and its requirements remains the same; only the planning-attribute values change.

Creating these models involves a great deal of clerical work. However, after you construct the business model and a number of planning models, you will find that you can reuse many dictionary specifications. For example, dictionary entries describing order-processing customers are reusable when you develop a market-survey planning model. The more you use upper CASE, the more reusable dictionary specifications you will have.

Every plan the company devises depends on timely information to ensure its success. Upper CASE systems contain planning specifications for functional activities and for developing information systems.

The Center

The Center for Advanced Information Management (CAIM) is a nonprofit organization affiliated with Auburn University. Its purpose is to provide an organization to facilitate research in the field of information engineering. This body consists of approved members from both the academic and business communities.

Objectives

The general goal of the CAIM is to provide a forum for research activities related to information needs and methods for satisfying these needs. Research interests include facilitating enterprise modeling, organizational planning, executive information systems, systems analysis and design, systems development, system maintenance, and network configuration and management; standardizing documentation; facilitating reverse engineering, computer-integrated manufacturing, real-time system development, and information resource management; providing assistance for project management; integrating organizational planning, systems analysis and design, systems development, information resource management, and project management; managing computer software configuration; and facilitating estimate acquisitions.

The long-range plan for the center leads to establishing international standards for various aspects of information engineering. In addition, the CAIM will institute a certification program for several areas of information management as well as initiate the *Journal of Information Engineering*. The first activity will furnish badly needed standards in information management for everything from file formats for project specifications to standards for methodologies and procedures. The remaining two activities will provide a mechanism for industry and academic professionals to acquire recognition and proficiency in information engineering through personal experience and access to the literature.

The CAIM will work closely with the International Standards Organization (ISO) and the United States of America Standards Institute (USASI) to establish standards for all aspects of information engineering.

Middle CASE

In middle CASE, you analyze problems with information and design solutions to them. Most middle CASE systems consist of diagramming and dictionary components operationally similar to those in upper CASE. However, the methodologies embodied in middle CASE are different. The combination of diagram and dictionary entries automates methodologies that systems analysts use. These systems also have special purposes for graphical icons and separate preformatted dictionary screens for describing how these icons symbolize real-world objects.

Manufacturers of middle CASE systems say that this software substantially reduces normal project-development life cycles. Another major benefit comes from storing the type of knowledge that usually resides only in the minds of systems analysts—their understanding of how the company functions and what its information needs are.

Very little information about how the company functions is directly related to the software that supports the company's operations. This information involves describing what departmental operations are and why they are important; why operations are performed in a certain way, what information supports them, and how that information is used; why certain conditions influence operations, what information about these conditions is needed, and why; responsibilities for various operations; job functions of personnel, and how and why information serves these job functions; and so on.

Middle CASE systems provide the structure to store this type of information and make it more accessible. You can gain years of experience about the company's operations and how it uses information simply by "mousing around" in design specifications.

It is often said that only 25 percent to 30 percent of middle CASE specifications is transportable to lower CASE systems. Lower CASE systems create the actual development specifications for programs. Since middle CASE specifications predominantly involve documenting a company's activities and the ways in which information serves it, only a small percentage of these specifica-

continued

tions is directly mapped into lower CASE systems. Some people question the need for middle CASE systems, but the expert knowledge contained in the middle CASE specifications provides a common base of knowledge that is invaluable.

Creating analysis and design specifications also involves a lot of clerical work. But once a number of systems have been modeled using middle CASE systems, many design specifications will be reusable. And as you continue to use middle CASE, reusable analysis and design specifications continue to multiply.

Lower CASE

Lower CASE uses a development software component to create a set of systems development specifications ultimately used to generate programs and in user documentation. The CASE development software system also contains a dictionary software system. However, it rarely provides a graphical component, since physically oriented development specifications don't usually need it. Lower CASE systems specifications are usually directly related to programs within the developed system.

Traditionally, a dictionary system documents the characteristics of the real-world entities being modeled. Thus, its specifications usually only provide a comprehensive reference for the modeled phenomena. The CASE development dictionary, on the other hand, is an *active* dictionary, which lets you enter specifications that both describe and influence the development of the modeled object by providing criteria for its development as well as references to its attributes.

An active dictionary comprises three major components:

- a database of empty storage buckets in which to store the characteristics of the computing environment and explicit characteristics of the applications systems;
- frameworks for procedural logic and specific types of procedural commands and modules contained within typical programs in the applications systems; and
- an *activator* capable of combining environmental and application characteristics with selected procedural-command frameworks and modules to produce application programs.

The database of empty storage areas provides the location in which to store the characteristics of the computing environment. Thus, it is less essential to describe the computing environment during applications development. These characteristics are stored in the active dictionary's database during installation of the CASE development system. Subsequently, systems developers enter the characteristics of individual application systems into the active dictionary's remaining storage areas. These characteristics define the attributes of the system being developed.

The frameworks for 14 types of logical routines used in typical business systems are also embedded in the active dictionary. Regardless of program style or language, business programs contain either a single logical routine or a combination of logical routines from within this basic set. Five are batch-processing routines, and nine are on-line processing routines. All involve either information-reporting or data-updating functions. To generate programs, the activator com-

continued

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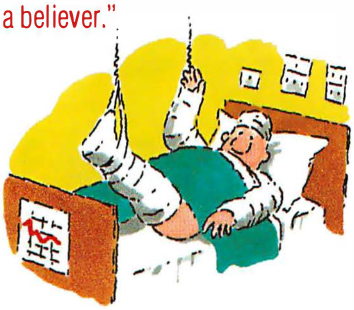
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bines appropriate frameworks and the database of systems and applications characteristics.

Creating development specifications also involves a lot of clerical work. However, once some systems have been developed using lower CASE, many development specifications are reusable. As you continue to use lower CASE, reusable development specifications continue to multiply. Thus, the benefits attributed to lower CASE continue to expand.

Finally, the CASE development system can generate development and user documentation and make it available in various formats.

The Benefits of Using CASE

The benefits of upper CASE are more direct if you usually perform corporate planning. By using an upper CASE system to build an enterprise model, you gain greater insight into the importance of certain functions and how the activities they control affect the entire organization. You can better understand

1. corporate and departmental mechanisms and responsibilities;
2. the goals of the company and its departments;
3. the influence of operations on achieving these goals;
4. their place within corporate and departmental administration and operations;
5. the timeliness and sequence of operations;
6. factors influencing operations and goal achievement;
7. allocation of resources in support of operations;
8. the effect of external influences on the organization;
9. problems facing the organization; and
10. the importance of information relative to the success of the organization.

Using upper CASE systems to develop planning models gives you a clearer understanding of the company's direction and how you can contribute to its success. These planning models let you assess the impact of changing values for certain planning specifications on corporate plans. You can perform "what if" analyses and assess worst-case and best-case scenarios. Thus, you can assess the impact of changing specifications prior to committing to these changes.

Models also provide the basis for project specifications. Many planning specifications can be mapped into project schedules, descriptions of activities and their time durations, and resource allocations, utilization, and costs. Vendors of upper CASE systems are trying to closely integrate their systems with commercially available project management software systems. They are trying to pass planning specifications entered into their systems to these project management systems. Thus, many initial activities performed during project management will be done without human intervention.

A major benefit of middle CASE is that it provides easier methods for changing systems design. It is also easier to determine that the analyst understands the problems and how to solve them. Design is inherently an iterative process:

- Users discuss their information needs with analysts;

continued

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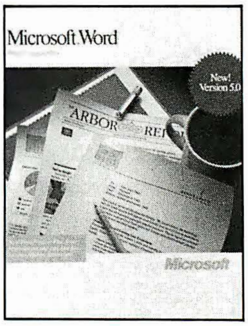
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- analysts use diagrams and dictionary entries to document them;
- users review these diagrams and dictionary entries and suggest modifications to them; and
- analysts respond to these suggestions by making appropriate changes to analysis and design specifications.

The last two steps continue until the analysis and design specifications more correctly correspond to what is needed.

A second benefit of middle CASE is that it facilitates joint applications-design sessions. In these sessions, systems professionals and end users rapidly interact and document the requirements for application systems. These sessions usually occur at the beginning of development projects and provide a jump start for the projects. As the interaction continues, its results are recorded in diagrams and preliminary dictionary entries. Thus, end users can directly and quickly influence analysis and design.

A third major benefit involves the prototyping facility that most middle CASE systems provide (see reference 7). This facility allows analysts to create screens to simulate the I/O screens and reports to be used as the end-user interface. These prototype screens are produced early in the analysis and design part of the project. You can use them to simulate data access and update functions. Prototyping lets you see how the completed system will service your information needs.

Lower CASE systems generate 60 percent to 80 percent of the program code in the system. As a result, the major benefit of lower CASE is the substantial reduction in the time required to actually develop the system. When lower CASE systems are used, the majority of time spent in systems development involves writing the customized code required for specialized processing.

A second major benefit concerns the ease of modifying systems generated by lower CASE systems. Since lower CASE systems generate the majority of code, maintenance activities usually only involve modifying any custom code. As a result, maintenance activities are less complicated and require less time, so requests for system modifications can be completed more rapidly. In addition, maintenance activities are performed through the active dictionary, which maintains a directory of the application programs and modules. Thus, the dictio-

continued

nary provides major assistance during maintenance activities.

A final major benefit involves lower CASE prototyping capabilities. Prototypes produced by most middle CASE systems require you to be logged onto the middle CASE system for prototype execution. As a result, prototype execution usually requires familiarity with the middle CASE system. Lower CASE systems produce prototypes that function like stand-alone systems, so you don't need specialized training to use them.

An Exciting Promise

CASE benefits you in many ways. You accrue benefits from each component of the CASE philosophy. The models created using CASE systems enable you to better understand your company and the conditions facing it. You can evaluate situations more judiciously and make more insightful decisions leading to better company performance. You can view the intent of systems design and influence its progress. And completed systems will be consistent with current organizational and departmental planning.

The promise of the CASE philosophy is an exciting one. As CASE continues to evolve, it will provide the framework needed for more timely and tightly integrated corporate planning and systems development. ■

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Methodology: The Experts Speak

Five prominent software engineers discuss the methodologies for which they are famous

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The Warnier/Orr Approach

Ken Orr

It's more or less impossible to write about the Warnier/Orr methodology because, in fact, there is no such thing. While there are Warnier/Orr diagrams, Warnier's methodology (i.e., logical data structure, logical construction of systems, and logical construction of programs), and Orr's methodology (data-structured systems development), there is not, strictly speaking, a Warnier/Orr methodology.

Many software engineers confuse diagrams with methodologies. Perhaps this is natural, since the diagrams are the most visible part of most methodologies; but it's unfortunate, for methodologies are much more than just a set of diagrams and syntax rules.

Within the context of software engineering, a *method* is a procedure or technique for performing some significant portion of the software life cycle. Over the years, techniques have been developed for requirements definition, database design, program design, test-case development, and so on. A *methodology*, in software engineering terms, is a collection of methods based on a common philosophy that fit together in a framework called the systems development *life cycle*.

Methods often use a variety of tools: diagrams, forms, and text for documenting and communicating. Not surprisingly, these diagrams and forms often take on a life of their own. Diagrams, like words, can be used out of context, without understanding the purpose for which they were intended. While the results can be confusing, new possibilities and uses often arise that are quite fortuitous.

People who develop software engineering methods and methodologies attempt to solve problems, observe what others do, and derive, or abstract, patterns from all this. Those patterns ultimately turn into methodologies.

In my experience, my colleagues and I always know *what* works long before we know *why* it works. Software engineering methodologists are skilled at working with experts, such as analysts, programmers, database administrators, and so forth, finding out how these experts do what they do, and putting these findings down in such a way that others can follow them.

The correct name for what many people call the Warnier/Orr methodology is data-structured systems development. DSSD, like most methodologies, is actually the result of many people's efforts, in addition to my own, including my coworkers at Optima, colleagues, and clients. Much of the methodology has come about by taking various component technologies, such as structured programming and relational-database design, and putting them together into a coherent framework.

A Little History

In 1972, Terry Baker's article "Chief Programmer Team Operations" in the *IBM Systems Journal* had a major impact on the field. It brought together several ideas: structured programming, top-down design and implementation, the chief programmer, the chief-programmer team, and the documentation librarian. If there was a shot that started the "structured revolution" in the U.S., Baker's article was it.

In the early 1970s, I became interested in structured programming and in structured design. In applying the principles of top-down design, I discovered that many of my best, most intelligible solutions were those in which the hierarchi-

continued

cal structure of the program mirrored the hierarchical structure of the data the program was processing.

Shortly after this discovery, I stumbled across the work of Jean Warnier and realized that he not only had made the same discovery with regard to data-structured programming but had already built a systematic methodology around it. I also followed Michael Jackson's work, another form of data-structured design.

I already believed that you could and should construct programs hierarchically using only a few basic logical structures. Moreover, I believed that if you were going to build very large things, you should build them in systematic ways based on simple structures. This coincided with design and construction techniques used in fields such as electrical engineering. Structured programming represented a base on which to build; therefore, using the data structure as the framework for building the program structure seemed like the next natural step.

Data-structured programming meant that you could create predictably correct solutions for a wide class of programming problems—problems in which the structures of the input and the output were the same or very similar. But beyond that, Warnier, Jackson, and those of us involved in developing DSSD were able to extend data-structured techniques to arbitrarily complex programs.

To solve these more complex problems, you must recognize that the nature of the problem of complexity is, on one level at least, fundamentally mathematical in nature—that is, complex problems are fundamentally *n:n* (many-to-many) mappings from input to output. To deal with this complexity systematically, you must break the problems down into a series of less complex mappings.

This is what mathematicians have been doing for thousands of years—breaking large troublesome problems into smaller ones for which there are clear precise answers. In the case of data-structured design, this meant developing a scheme in which the physical inputs were mapped into logical inputs; the logical inputs were then mapped into the logical outputs; and, finally, the logical outputs were mapped into the physical outputs.

With this overall program-design framework comes a goal-oriented design strategy—an approach that starts *with* the structure of the output and works backward, first to the logical, or ideal, input, and then to the physical input.

The data-structured approach to program design has proven to be successful on a wide variety of problems, but it is clearly no panacea. What it does represent is a systematic approach to attacking complex problems (simple problems have a way of taking care of themselves, or, alternatively, becoming complex).

Programming in the Large

At some point in developing techniques for building systems, you realize that the most significant problems in software occur not at the programming level but at the systems level. How do you design entire suites of programs so that they work effectively together? How do you get the right requirements? Where does planning fit into the scheme of things?

Little by little, DSSD moved from a program-design methodology to a systems-design methodology. Over a period of years, the methodology was expanded to deal with database design, require-

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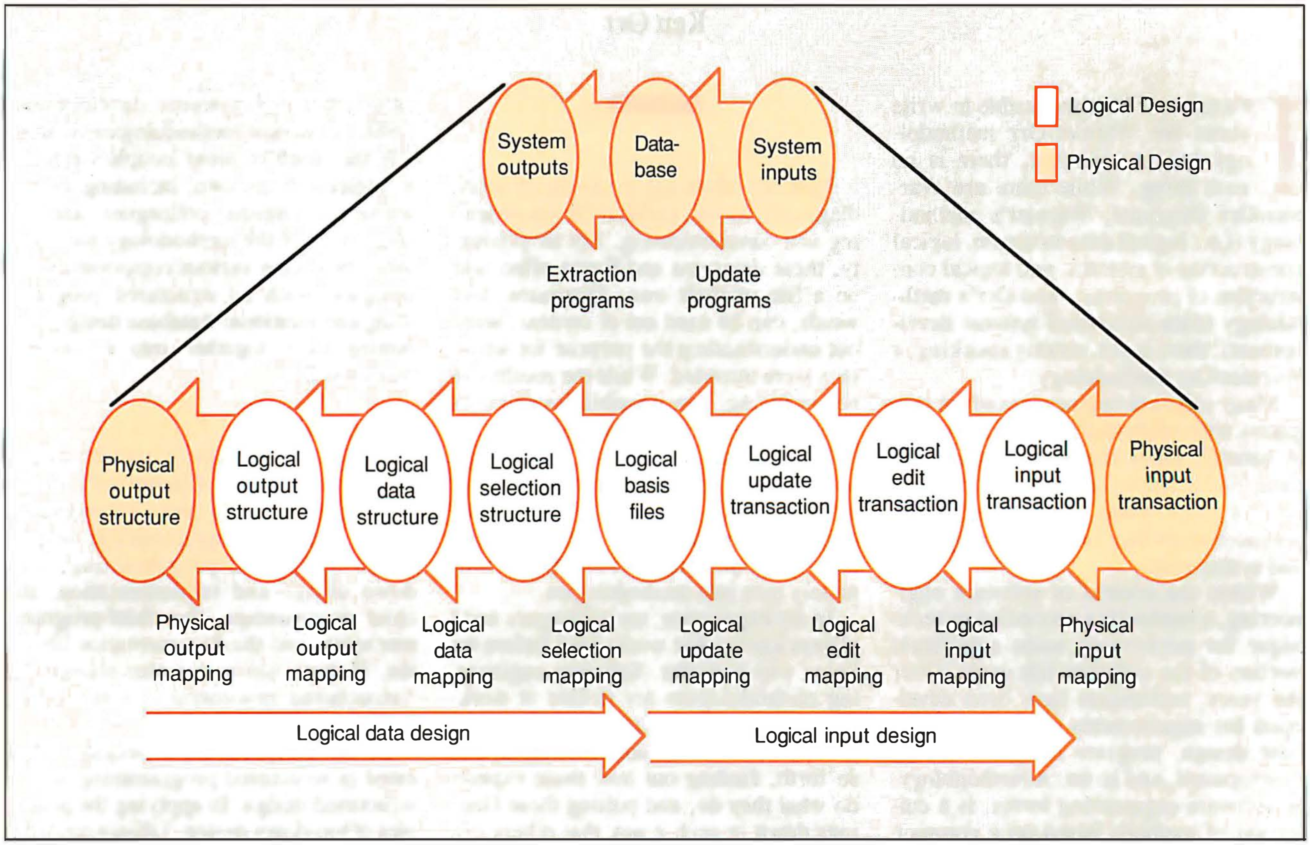


Figure 1: *At the systems level, instead of working backward to the ideal inputs, DSSD works backward to the logical database and then to the inputs.*

ments definition, and finally systems planning and architecture.

At a conceptual level, DSSD still retains features that characterized it at the programming level. For example, it still focuses (in its design phase) on working backward from outputs. But at the systems level, instead of working backward to the ideal inputs, as it does in the programming methodology, DSSD works backward to the logical database and then to the inputs (see figure 1). The logical database turns out, not surprisingly, to be a normalized relational database.

While a complete definition of the results (outputs plus algorithms) is an excellent point at which to begin the design process, it is not the proper place to start requirements definition. So, over the years, DSSD has been extended to cover first the context, then the functions, and finally the results of the system in question.

Thus, a number of tools were needed to facilitate this process. *Entity diagrams* help you define the systems context, and *assembly-line diagrams* (a modified form of Warnier/Orr diagrams) help you define the functional flow of the system.

Data-structured methodologies have, I believe, a leg up on more process-oriented methodologies, since they are more rigorous and hence provide a better basis for true integration throughout the systems life cycle. DSSD has been used successfully on a range of software systems, from commercial on-line systems to real-time control systems. Thousands of people have been trained and thousands of systems have been built using it.

DSSD is a software engineering approach that has provided a stable framework for incorporating new technologies as they come along. For example, we have incorporated prototyping, on-line, and real-time design into DSSD without sacrificing the rigor or completeness. But there is a catch: To use DSSD successfully, you must invest time in training, use, and automation. In software engineering, as in life, there is no free lunch.

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The Gane/Sarson Approach

Chris Gane

When we think about an information system that doesn't exist yet, our ideas are usually pretty vague and general. This is not an accusation; it's a fact of human psychology.

The purpose of logical modeling is to take these necessarily vague ideas about requirements and convert them into precise definitions as fast as possible. Part of the speed comes from having graphical techniques that enable you to put down the essence of a system without going through the trouble of actually physically implementing it, as you might do, for example, in a prototype.

Several approaches to logical modeling have been proposed. The one outlined here is the current version of the approach set out in a book I wrote with Trish Sarson (see reference 1). It has become generally known as the Gane/Sarson methodology.

Logical Modeling

You can think of logical modeling as a seven-step process. Suppose the users say, "We need a system that integrates sales, inventory control, and purchasing." What exactly does that mean?

• *Step 1.* Develop a system-wide data-flow diagram (DFD) describing the underlying nature of what occurs in the sales, inventory control, and purchasing areas of the business. The simplicity of the DFD comes from the use of only four symbols to produce a picture of the underlying logical nature of any information system, at any desired level of detail.

Figure 1 shows CUSTOMERS (an external entity, something outside the system) sending in a stream of sales orders along the data-flow arrow. Process 1, process sales, handles those orders using product information from the data store called D1: PRODUCTS and puts information about sales into the data store named D3: SALES.

This figure also shows the whole of the business area, depicted using only the four symbols. For each sale, process 1 updates the INVENTORY data store, D2, with the units sold. The data stored in D3 is used by processes 2 and 3 to prepare bank deposit documents and send them to the bank, and to prepare sales reports and send them to management.

At some appropriate time—notice that time is not shown on the DFD—process 4 extracts information about the inventory status of various products from D2 and combines it with information from D3 concerning their past sales, to determine whether a product needs to be reordered. If so, based on information in D4, which describes the prices and delivery times quoted by suppliers, process 4 chooses the best supplier to order from.

Process 4 sends purchase orders to the external entity SUPPLIERS and stores information about each purchase order in D5: POS_IN_PROGRESS. When a shipment is received from a supplier, process 5 analyzes it, extracting data from POS_IN_PROGRESS to determine whether what has been received is what

continued

was ordered, incrementing the INVENTORY, D2, with the accepted amount, and storing the accepted quantities in POS_IN_PROGRESS.

This DFD achieves three things. First, it sets a boundary to the area of the system and of the business covered by the system. Things represented by the external-entity symbol (i.e., customers, the bank, management, and suppliers) are, by definition, outside the system. Processes not shown are not part of the project. For example, the diagram shows receiving shipments from suppliers but not handling the invoices received from them, implying that accounts payable is outside the scope of the project as well.

Second, it is nontechnical. Nothing is shown on a DFD that is not easily understandable to people familiar with the business area depicted, whether or not they know anything about computers.

Third, it shows both the data stored in the system and the processes that transform that data. It shows the relationships between the data and the processes in the system.

• *Step 2.* Derive a first-cut data model—that is, a list of the data elements to be stored in each data store, as defined on the DFD. You should draw up this list from your own knowledge and from the knowledge of users about what information you need to describe a product, a supplier, a sale, and so on.

You can refine the list by looking at each system input, such as sales orders or shipments in figure 1, determining what data elements each input represents, looking at each output in the same way, and then working from the outputs back to the data stores or from the inputs forward to the data stores.

• *Step 3.* See what entity-relationship analysis can tell you about the structure of the data to be stored in the system. First, you ask, "What are the entities of interest about which I may need to store data?" For this business, the answer might be CUSTOMERS, PRODUCTS, INVENTORY, SUPPLIERS, SALES, and PURCHASE_ORDERS. Then, you create a diagram with a block for each entity you have identified. (It is conventional in this diagram to state the entities as singular nouns—for example, CUSTOMER instead of CUSTOMERS.)

Next, looking at each pair of entities on the diagram, you ask, "What, if any, relationships exist between them?" For example, you know that one customer may be associated with many sales, but each sale can be for only one customer. This is conventionally shown by a line with an arrowhead against the "many" block and a plain line at the "one" block.

Take, for instance, PRODUCT and SALE: One product may be associated with many sales, and one sale may be for many products—at least one, and possi-

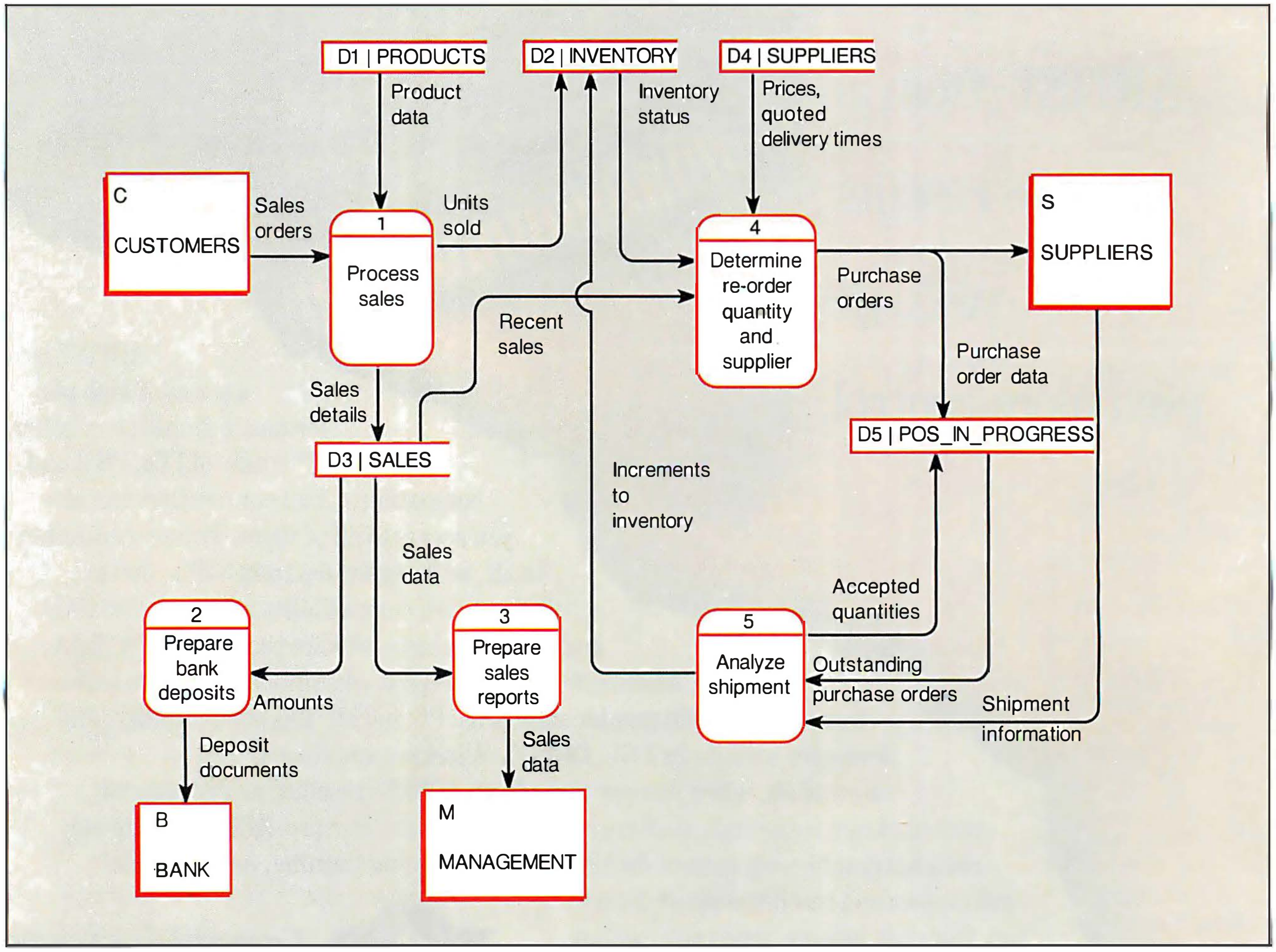


Figure 1: *A DFD for the whole of the business area. Note the box for external entities, the open rectangles for data stores, the rounded box for the process, and the data-flow arrow, which shows the direction of data movement. Notice also that time is not shown on a DFD.*

bly more. This relationship is shown by a line with an arrowhead on both ends. On the other hand, each product has only one inventory record, and each inventory record refers to only one product. Consequently, they are joined by a simple line. Adding in all the identifiable relationships creates a diagram like figure 2.

• *Step 4.* Use all the information you have about the data so far to describe the data model as one made of linked, two-dimensional tables. These tables should be *normalized* (i.e., made as simple as possible). One way to summarize the rules of normalization is to say that in a properly simplified table, in which a column or combination of columns uniquely identifies each row (the key), each nonkey column should depend only on the key.

• *Step 5.* Redraft the DFD to reflect a more precise view of the system data as a result of entity-relationship analysis and normalization.

• *Step 6.* Partition this logical model of process and data into *procedure units*—that is, chunks of automated and manual procedures that can be executed (and therefore developed) as units. To do this, you consider each input and output and ask the following questions for each one:

1. When does it happen?
2. How large an area of the DFD is involved in handling or producing it?
3. Can that area be implemented as a single unit? If not, why not?

• *Step 7.* Specify the details of each procedure unit that will be required to implement the system. A procedure-unit specification may involve

1. an extract from the system DFD showing where this procedure unit fits into the rest of the system;
2. details of the tables accessed by the procedure unit;
3. layouts for any screens and reports involved in the procedure unit; and
4. details of the logic and procedures to be implemented, written in structured English or some other unambiguous form.

With the nature of the procedure unit defined, you can decide whether it should be prototyped or implemented directly in the target language. You can develop the screen and report layouts by prototyping.

Steps 6 and 7 in this sequence are not, strictly speaking, logical modeling, since they deal with converting the logical model into a physical model. They are included, however, because they form part of the natural flow of thought processes beginning with defining the system and ending in its physical design.

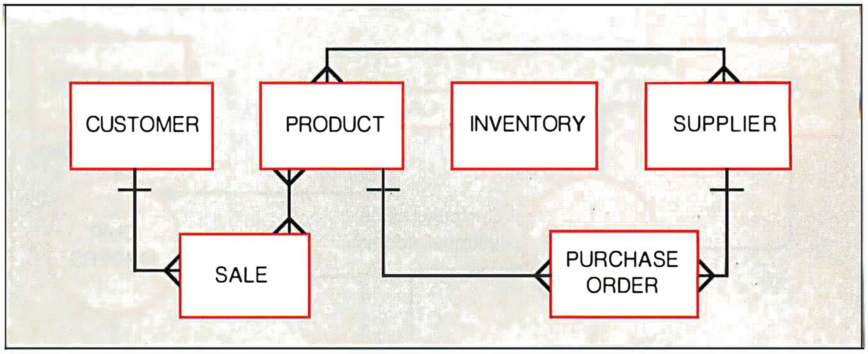


Figure 2: *All the identifiable relationships between entities. For each pair of entities on the diagram that has a relationship between its elements, the relationship may be one-to-one, one-to-many, many-to-one, or many-to-many. This diagram provides a lot of information about the system in showing all the relationships that exist between the entities involved.*

Editor's note: *Chris Gane extracted this article from Chapter 1 of his book* Rapid System Development, *published by Prentice-Hall in December 1988.*

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The Yourdon Approach

Edward Yourdon

The Yourdon method is a generic, ecumenical collection of software engineering ideas developed over the past 20 years by a variety of people who have worked at Yourdon, Inc. Taken together, these ideas are often referred to as *structured techniques*: structured programming, structured design, and structured analysis.

Because of the continuing influx of new ideas from new people, the Yourdon method is constantly evolving. The method that thousands read about in Tom DeMarco's book in 1978 (see reference 1) has changed considerably in the past 10 years. And the Yourdon method of 1989 is evolving to incorporate the best ideas of object-oriented design and analysis.

But what *is* the "Yourdon method" today? It consists of two things: tools and techniques. The tools are a variety of graphical diagrams used to model the requirements and the architecture of an information system. The most familiar of these tools is the data-flow diagram (DFD) (see figure 1). The original DFD notation was extended a few years ago to support real-time systems; a real-time DFD includes control flows and control processes. For a detailed description of

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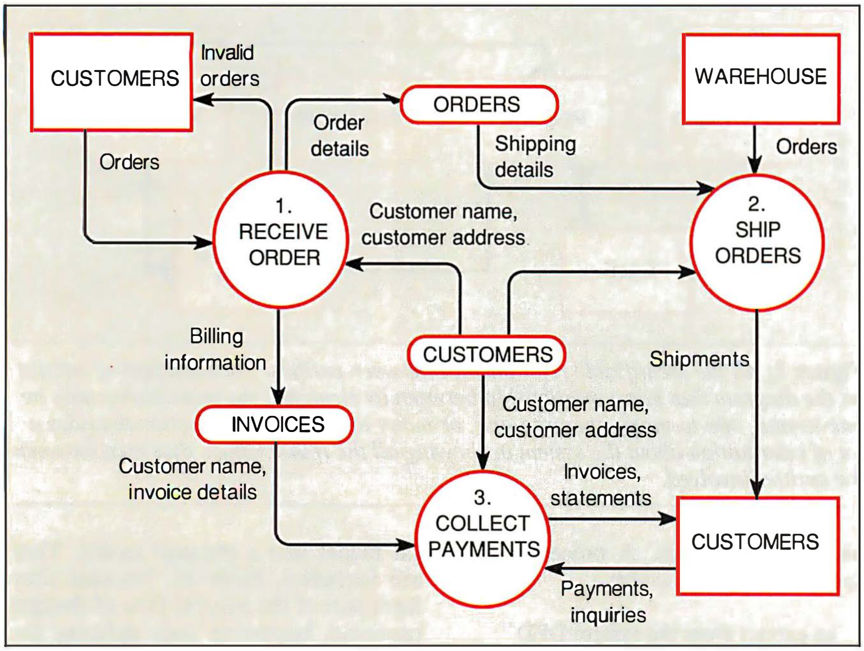


Figure 1: *A data-flow diagram. The DFD models the functions that a system must perform.*

real-time DFDs, see reference 2.

While the DFD is an excellent tool for modeling the *functions* that a system must carry out, it says little or nothing about data relationships and time-dependent behavior. Thus, the current Yourdon method also includes entity-relationship diagrams (ERDs) and state-transition diagrams (STDs) (see reference 3).

After you have finished describing the system requirements, you can use a structure chart to illustrate the organization of modules that will implement those requirements. A number of guidelines exist that the systems analyst can follow to ensure that each diagram is complete and logically consistent.

While the graphical diagrams provide an effective way of communicating information about different aspects of a system, they don't tell the whole story. For a complete system description, you need additional textual support: a data dictionary, which describes the composition of each data element, and a set of process specifications that describe the required behavior of each bottom-level "bubble" in the DFD.

The Techniques

The techniques of the Yourdon method consist of some "cookbook" guidelines that help you go from a blank sheet of paper, or a blank screen, to a well-organized system model. Originally, these guidelines were based on the simple concept of top-down partitioning of system functions (e.g., draw a single bubble or box to represent the entire system, then draw lower-level bubbles or boxes to represent subsystems, and so forth).

Today, the Yourdon method uses a technique known as *event partitioning* (see reference 4). This approach begins by drawing a top-level *context diagram* to identify the system boundary and to define the interfaces between the system and external sources and sinks. Then, after interviewing the user, you can write a list of the *events* that occur in the external environment and to which the system must respond. (Events are often input transactions.)

The event-partitioning approach provides a simple guideline to help you compose a first-cut crude DFD: For each event, draw one bubble whose function is to provide the required response to the event. (In most cases, the response involves generating an output, but it may also involve storing some information in a data store to be used by some subsequent event.)

For a system with 100 events, the DFD would have 100 bubbles. This is too complex to work with, so the event-partitioning technique provides guidelines to help you partition *upward*—that is, to gather several of the DFD bubbles together and represent them by a single bubble in a higher-level DFD. The strategy for deciding which bubbles should be grouped together is to look for bubbles that deal with common data (e.g., a common data store). In this sense, event partitioning is very similar to the object-oriented design approach.

There are various additional guidelines and techniques to help you compose well-formed models of both system requirements and system architecture. (One book that discusses both the analysis area and the design area—as well as the "twilight zone" that separates the two—is given in reference 5.)

The Yourdon Philosophy

Throughout all of the Yourdon method—regardless of variant or dialect, whether you draw circles or ovals in your DFD, or where you hear about it—you will see the following philosophies.

• *Modeling is good.* Developing a model of a system before you build it is almost always a useful, educational activity. For this to work, however, the model has to be inexpensive and easy to build: If it costs as much to develop the model as to develop the system, it's obviously a waste of time. The model also has to be accurate—it should not mislead you or lie to you. And it should be easy to understand: It should highlight those aspects of the system that are important, and it should deemphasize or hide those aspects that are unimportant or uninteresting.

Since most systems are complex in three different dimensions—functions, data, and timing and control—it is useful to have three different types of models, DFDs, ERDs, and STDs, each of which illustrates a single perspective of the system. The Yourdon method is based on abstract, pictorial models—either on paper or on a computer screen.

Another approach is to develop a prototype of the system as a model—a living, breathing model instead of a passive collection of diagrams. When prototyping was first introduced in the early 1980s, it was considered an alternative to paper-based modeling approaches—the systems analyst was often told to make a binary choice between prototyping and drawing DFDs.

Today, we know that the two approaches are complementary: You can draw diagrams as a permanent record of system requirements and use prototyping to experiment with such key issues as the user interface (input screens, report layouts, and so on). For a good discussion of the marriage of prototyping and "classical" structured analysis, see reference 6.

• *Iteration is good.* As fallible humans with limited intelligence, we rarely, if

continued

ever, develop a perfect solution to a complex problem on the first attempt. At best, we can hope for a crude beginning that, through iteration, we can gradually refine and improve. To practice iteration, we must have models that are easy to create and easy to revise. In the past, we grappled with the finality of pen and ink; with the word processors of today, most of us take iteration for granted in composing reports and memos.

In systems development, we tried to make iteration of system models easier by insisting on partitioning the overall system model into a number of separable submodels. Thus, if one aspect of a system changes, ideally only one page of a diagram has to be modified. As a practical matter, though, most systems analysts in the 1970s and early 1980s drew DFDs only once—on paper. This is one reason why today's microcomputer-based computer-aided software engineering products are so important: They make iteration a practical reality.

• *Partitioning is good.* When we first learned how to write computer programs, we were given simple problems that we could finish in a day or two, keeping every aspect of the problem in our heads at once. With real-world programming problems, however, the only way we can successfully build systems that, today, typically involve more than a million lines of code is by partitioning the system into smaller and smaller pieces.

There are great debates about whether the partitioning should be based on functional decomposition or data decomposition. But either approach, followed rigorously, is better than no partitioning, or sloppy partitioning that leads to subsystems with subtle, pathological interconnections.

ACKNOWLEDGMENTS
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The Entity-Relationship Approach

Peter P. Chen

One of the major problems in software engineering today is the piecemeal approach to systems design. This approach makes the integration of different application systems difficult, if not impossible. We try to design the data structures and formats to fit current processing needs and then later run into problems of data conversion and integration.

An integrated database is a solution to these problems. However, acquiring a DBMS does not make them go away. What is needed is a structured methodology that can systematically convert user requirements into well-designed databases. The entity-relationship (ER) approach is such a methodology.

Let's start with an example. Say you need a program to keep track of the list of employees working for each department in your company. This program needs to accept data on the screen, store it on disk, and print out the report on demand. The programmer/analyst comes up with a file format (see figure 1a).

In the meantime, another group in the company implements a program to keep track of employee information for each project; the file format in this program turns out a little different from the other (see figure 1b). Each program satisfies the needs of the group that requested it. However, one day the company president wants to know which departments have employees working on project X. Then everyone scrambles around trying to convert the data in one file to the format of the other file. Let's look deeply into these two file formats to see what kinds of problems they had.

- Synonym (the same data element has different names): For example, SOC_SEC_NO in figure 1a is the same data element as SS# in figure 1b.
- The same name for different data elements: For example, NAME in figure 1a refers to the name of an employee, while NAME in figure 1b is the name of a project.
- Incompatibility of data formats: For example, the data-type format of AGE in figure 1a is Int(2), while the data format of AGE in figure 1b is Real(3.2).
- Duplication of data: For example, the project data (PROJ#, NAME) is duplicated for each employee associated with the project in figure 1b, and the BUDGET data of each department in figure 1a is repeated for each employee.
- Update anomalies: For example, changing any of an employee's data-element values in one file but not in the other will result in inconsistent data.

If the above file designs are not good, what would be a good design? How many record types (or relations in the case of relational databases) should there be? Should there be one huge record type

consisting of all data elements, or the other extreme—many small records, each consisting of a pair of data elements? Furthermore, what is the primary key for each record (relation) type? The main question is: Do we have a methodology for file and database design? The answer is yes, and the leading methodology is the ER approach.

Six years ago, a survey of Fortune 500 companies (published in ACM SIGMOD proceedings, 1983) conducted by two Ohio professors showed that the ER methodology ranked as the most popular methodology in data modeling and database design. Why? Because it is simple, easy to understand by noncomputer people, and theoretically sound. To illustrate, here are the major steps of the ER approach using the above example:

• *Develop an entity-relationship diagram (ERD).* This step identifies ER types and associated attributes and also the primary keys for each entity type.

An *entity* is a thing (e.g., a person or an automobile), a concept, an organization, or an event of interest to the organization doing the modeling. An *entity type* is a classification of entities satisfying certain criteria. A *relationship* is an interaction between entities. A *relationship type* is a classification of relationships based on certain criteria. Usually, nouns in English correspond to entities, while verbs correspond to relationships.

In the example in figures 1a and 1b, you can identify three entity types: DEPT, EMP, and PROJ. You can also identify two relationship types: HAS and WORK_FOR (note that relationship-type names are verbs). Figure 2 depicts an ERD in which rectangular boxes represent entity types and diamond-shaped boxes represent relationship types.

The next step is to identify the *cardinality* of the relationship types. The cardinality of HAS (between DEPT and EMP) is 1:*n* (one-to-many); that means a department can have many employees, but each belongs to at most one department. The cardinality of WORK_FOR (between EMP and PROJ) is *n*:*n* (many-to-many). You then identify the properties (attributes) of each ER and express them graphically as circles (or ellipses). For example, each DEPT has attributes DEPT# and BUDGET. The primary key is indicated by a double circle. Note that there is an attribute called %TIME for relationship WORK_FOR.

• *Convert the ERD into conventional file and database structures.* There are rules for doing this. For example, you can convert the ERD in figure 2 into the relational structure with all the primary keys underlined.

DEPT(<u>DEPT#</u>, BUDGET)
EMP(<u>SS#</u>, NAME, AGE, DEPT#)
PROJECT (<u>PROJ#</u>, PNAME)
WORK_FOR(<u>SS#</u>, <u>PROJ#</u>, %TIME)

Simply speaking, each entity type is converted into a relation, and a relationship type is converted into a stand-alone relation or consolidated with another relation, depending on the cardinality of the relationship.

If you are familiar with relational normalization theory, you can prove that these relations are in Third Normal Form. As you can see, all the primary keys of the relations are derived automatically, and DEPT# in EMP relation is a *foreign* key (i.e., the primary key of another relation—DEPT).

• *Develop application programs based on the file and database structures.* If you are using a relational DBMS, you can now write a System Query Language (SQL) program to express the question, Which departments have employees working on project X?

```
SELECT EMP.DEPT#
FROM EMP, WORK_FOR
WHERE (WORK_FOR.PROJ# = X)
AND(WORK_FOR.SS# = EMP.SS#)
```

This article shows how to design a relational database based on the ER approach. Similarly, you can design file structures and various other databases—from microcomputer-based DBMSes,

continued

a)

Layout	SOC_SEC_NO	NAME	AGE	DEPT#	BUDGET
Format	Char(9)	Char(20)	Int(2)	Int(3)	Int(9)

b)

Layout	SS#	EMP_NAME	AGE	PROJ#	NAME	%TIME
Format	Char(9)	Char(20)	Real(3.2)	Int(4)	Char(30)	Int(2)

Figure 1: (a) *File format for the program to list employees in each department.* **(b)** *File format for the program to list projects for each employee.*

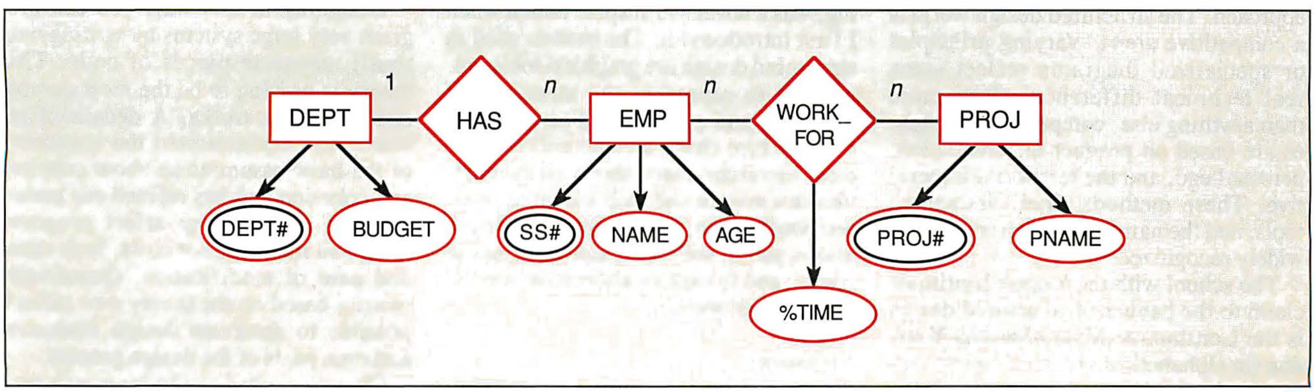


Figure 2: *Entity-relationship diagram (ERD) for a database based on figure 1.*

such as dBASE, to mainframe-based DBMSes, such as DB2 and IMS—based on the ER approach.

Future Trends

You have seen how to design a database and an application program based on the ER approach. The resultant database is sound and avoids such problems as data duplication and update anomalies. Commercial tools are available today to automate the ER approach.

The ER model can be used not only as a design tool but also as the underlying model for a DBMS. In the microcomputer and minicomputer range, Zanthe (Ottawa) has a product called ZIM. In the mainframe area, several computer vendors have ER-like DBMSes ready for marketing. For example, Software AG has ADABAS/Entire, and Unisys has SIM as part of its InfoExec offering.

On another front, ANSI recently approved an Information Resource Dictionary Systems standard based on the ER model. In the near future, we'll see a flood of IRDS products as well as computer-aided software engineering tools based on the ER model.

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The Structured-Design Approach

Larry L. Constantine

The computer field likes big words. Why call something an *instance* when *instantiation* works just as well, even if it isn't in the dictionary? A software design *method* sounds like the sort of generic-brand thinking that anyone could work out over a long weekend. But a software design *methodology* sounds like an elaborate and well-thought-out concept, perhaps worth attending a seminar on by a major software guru, and certainly worth the price of a book. However, *methodology* actually means the study of methods, and *software methodology* is an ungrammatical use of the word.

Structured design is both a generic term for various systematic approaches to designing program structure and also a kind of brand name for one particular approach. The structured design world is a competitive arena. Varying principles or specialized diagrams reflect some real technical differences. But, more than anything else, competing approaches are based on product differentiation, personal ego, and the territorial imperative. These methods, their associated tools, and the names of the principals are widely recognized.

The school with the longest legitimate claim to the banner of structured design is the Constantine-Myers-Stevens-Yourdon (in alphabetical order, of course) approach that I originated in the late 1960s. It begins with a data-flow diagram (DFD) (often called a "bubble chart") showing the transformational structure of an information-processing problem; then it derives a model of the modular structure of software that will solve that problem.

Models

Much is made of design methods, but structured design is really powered by a *troika* consisting of models, methods, and measures (see figure 1). The models make it possible to picture and play with the modular structure of software systems without actually having to program them first.

System-structure modeling, now accepted as essential to software engineering, was a novel and suspect notion when I first introduced it. The models used in structured design are graphical tools, annotated to represent the structure of problems and programs. For example, the structure chart, an elaboration of the older hierarchy chart, shows all the modules in a system and their essential interrelationships in one compact model. It allows you to see the "shape of things to come" and to explore alternative ways to organize software.

Measures

Structured design, unlike some other structured techniques and software engineering "methodologies," is grounded in a body of underlying theory about what makes programs complicated to build right in the first place and difficult to change in the second. The practical embodiment of this theory takes the form of two measures—coupling and cohesion—that index the relative complexity or difficulty of various designs.

Simple programs are, simply put, made out of little pieces, each of which is easily thought of as a unit or a whole that is mostly independent of other pieces. Module cohesion is a measure of module "wholeness," and coupling measures interdependence. In other words, good designs that are easy to build and change are based on a bunch of modules, each of which is "cohesive," or well-glued together, and only loosely "coupled" to other modules.

Designing in this way, you can program very large systems by writing only small, separate pieces of code. This theory is proving to be the most durable element of the troika. A decade of research has demonstrated the soundness of the basic assumptions about coupling and cohesion and has refined our understanding of how they affect programming and maintenance costs, fault rates, and ease of modification. Quantitative metrics based on the theory now make it possible to automate design evaluation and even parts of the design process.

Object-oriented methods are emerging as major factors in software engineering, but even with these powerful new tech-

niques, the cohesion of actual modules that implement object classes and their coupling with other modules turn out to be important for building simple systems with truly reusable components. As a consequence, the original measures of coupling and cohesion have now been extended and adapted to evaluate the quality of so-called object class modules and abstract data types.

Methods

Methods is the weak third member of the structured design team, but the one that gets much of the attention. The methods of structured design include a loose collection of rules and some moderately systematic strategies for the step-by-step design of software. These strategies are based on specific kinds of software organization that have proved effective in practice. Among the most durable are the balanced system structure known as *transform-centered* organization and the event-oriented organization called *transaction-centered.* Distinct design methods are aimed at producing each variation on system organization.

You might outline an overall structured design method as follows:

1. Develop a nonprocedural (method-independent) statement of the system requirements, usually centered around a DFD.
2. Based on the structure of the problem, choose an appropriate software organizational model or combination.
3. Guided by the data flow and the chosen organizational model, decompose overall functions into subfunctions and compose primitive functions into higher-level functions until the complete requirements are satisfied.
4. Using various design rules and measures of coupling and cohesion, refine the design for increased modularity, extensibility, and likely reusability of modules.
5. Complete detailed designs as necessary for all modules.

The problem, of course, is that actually carrying out the modeling, evaluation, and refinement involved in structured design takes discipline and time, uses a lot of paper, and can wear out the erasers on every pencil in the office. Unaided by computer tools, many developers who use structured design have used it informally and unsystematically, while others have used its concepts to shape their thinking without ever applying the formal models, measures, and methods.

Automating Methods

Computer-aided software engineering is not a replacement or substitute for systematic methods; it's the key that unlocks their full potential. With CASE tools, real structured design on problems of interesting size becomes truly practicable for the first time. The diagram editors of CASE systems assist in developing and refining complex graphical models. CASE tools with built-in knowledge of the models' meaning can check them for consistency and conformance with the established rules of structured design.

With intelligence about good designs incorporated into CASE tools, the computer can evaluate the quality of actual structured designs or even sketch out a rough initial design. At present, the most advanced CASE workbenches provide powerful support for existing software engineering methods; in the future, new structured methods are likely to be developed based on the use of quasi-intelligent CASE tools.

CASE systems can also reinforce or impose standards for software architectures and the diagrams that document them, but CASE vendors have yet to take on much responsibility for standardization. Most of the available tools and workbenches are methodology-independent—meaning you can use them to do any brand of design, structured or unstructured, that you may choose.

This may be an acceptable level of flexibility, given the state of the science in "computer science," but some of these tools have arbitrarily departed from what few standards and conventions do exist. It doesn't make sense for a system to use its own peculiar icon for an included module any more than to allow a CAD/CAM system for electrical engineers to use just any old shape to represent a transistor.

If we use computer-aided software engineering tools, and we call ourselves software engineers, perhaps it's time we acted more like engineers. ■

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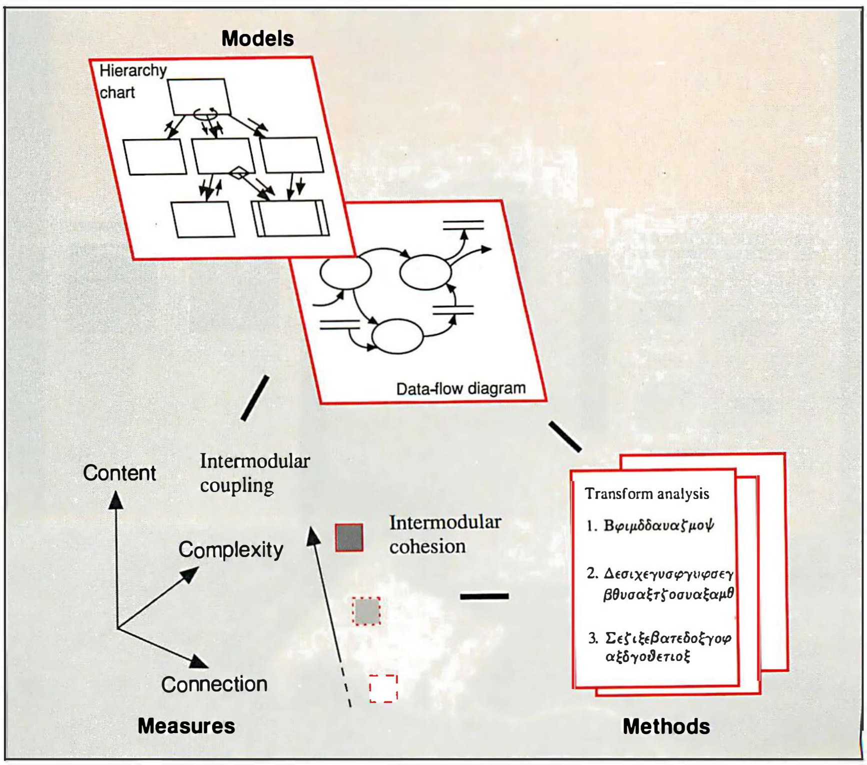


Figure 1: *The troika of structured design: models, methods, and measures.*

 Circle 324 on Reader Service Card

The CASE Experience

CASE works. But do you need a tool, a toolkit, or a workbench? And how do you begin?

Carma McClure



Do you believe in software automation as the key to increasing productivity, controlling quality, and introducing predictability into the software process?

Touche-Ross does. It's betting its ability to build client applications with analyst-only teams on software automation.

Deere & Co. does. It believes that automation is the answer to productivity gains on the shop floor and should be the answer to needed productivity improvements in its MIS department as well.

So does DuPont. It's offering a money-back guarantee that its people can custom-build applications that meet user satisfaction and schedules with the aid of software automation.

These organizations first proclaimed their belief in software automation three years ago when they each reported that using computer-aided software engineering (CASE) technology had a positive effect on software productivity and quality. (See the text box "A CASE of Three" on page 236.) Today, their belief in software automation is as strong as ever. Because of successful experiences with CASE, they are using more CASE tools to build all types of software systems and are even venturing into new business directions.

CASE technology is replacing paper and pencil with the computer to transform software development into an automated process. Simply defined, CASE *is* software automation. The basic idea underlying CASE is to provide a set of well-integrated, labor-saving tools that automate software development and maintenance work.

CASE is a combination of software tools and structured software development methodologies. The tools automate the software process, and the methodologies define the process to be automated. CASE technology focuses on the productivity of business, real-time, and scientific-software systems developers. With the use of personal computers and workstations, LANs, and CASE tools, software developers can work from a highly responsive, dedicated environment to develop and maintain software systems.

CASE Tools

CASE tools are a new breed of graphics-oriented, microcomputer-based software tools (see figures 1 through 4). As the notion of CASE evolved over the last five years, the definition of a CASE tool broadened from meaning simple systems analysis and documentation tools to include full-function tools providing automated support for the entire software life-cycle process. The broadest definition of a CASE tool is any software tool that provides automated assistance for software

continued

A CASE of Three

Touche-Ross

In the summer of 1986, Touche-Ross of Milwaukee, Wisconsin, was an avid user of Excelerator, the CASE toolkit from Index Technology. Touche-Ross prided itself on being an early believer in CASE and was one of the first users of Excelerator. During the previous two years, it had equipped its teams of systems analysts, who had been trained in the Yourdon school of structured methodologies, with over 100 copies of Excelerator, POSE from Computer Systems Advisers, Visible Analyst from Visible Systems, and DesignAid from Nastec.

These IBM PC–based CASE toolkits were used in the creation of requirements specifications for information systems, such as order entry, inventory control, and a bidding system. The Touche-Ross experiences with analyst/design toolkits whetted its appetite for more automated assistance of the software process and for more CASE tools to automate additional software tasks. Touche-Ross recently added the Information Engineering Facility (IEF), the CASE workbench from Texas Instruments, to its set of CASE tools.

Touche-Ross found that accomplishing individual software tasks with the aid of CASE tools is easy, but even with them, the whole software process is still horrible if you don't understand what to do with the tools. Because a software development methodology is a good guide to what exactly is to be done when building a software system, Touche-Ross has trained its systems analysts in a full life-cycle methodology: information engineering. Training for the IEF workbench and the information engineering methodology requires three to four weeks at a cost of $10,000 per analyst.

Expanding its horizon for more software automation, Touche-Ross is now using CASE tools to support strategic systems planning, system requirements specification, systems design, and code generation tasks. Touche-Ross is also expanding its belief in what software automation can do in practice today. It believes that with the use of CASE tools, its systems analysts can custom-build application systems for clients.

The interesting point here is that there are no programmers at Touche-Ross. Both software development and software maintenance will be done without programmers. The company believes that the CASE technology is now mature enough to support this tremendous and daring change. According to Touche-Ross, the payoff from using CASE will come from its ability to produce higher-quality software products in the same amount of time and to greatly reduce software maintenance.

Touche-Ross's advice to newcomers to the CASE technology is to start now and start slowly with a pilot project.

Deere & Co.

When searching for a better way to manage data, the data administration group at Deere & Co. in Moline, Illinois, discovered CASE tools. Deere has been using CASE since 1985 when it installed 10 copies of the IBM PC–based Information Engineering Workbench from KnowledgeWare. Deere's systems analysts used the IEW to support requirements analysis and the data analysis tasks performed during the first two software development phases. In 1986, Deere viewed CASE tools as the means whereby software developers could do more work in less time, do a better job of specifying system requirements, and reduce the software maintenance effort.

During the past two years, both Deere's experience with CASE and the CASE tools themselves have matured. Deere believes that CASE is helping it do a better job of developing software systems. However, it's impossible to quantify how much better because Deere, like many other organizations, has no base against which to measure. Deere believes that even a 1 percent productivity improvement means a lot of savings. Also, with CASE, Deere is taking systems knowledge out of the heads of software developers and putting it into the CASE tool repository to create an infrastructure of reusable systems information. In the long term, this will lead to the greatest productivity gains.

When recently asked for an update on its use of CASE, Deere & Co. said it's basically more of the same. Deere currently has installed 39 copies of the IEW as well as APS, the COBOL code generator from Sage Software. While approximately 30 analysts are now using CASE tools, Deere plans to raise this to 125 analysts over the next three years.

Deere's CASE implementation strategy is to "go slowly and easily." It began by defining what its software needs were and then finding the software development methodology and CASE tools to address those needs. Deere started small with an initial CASE investment of $25,000. Starting small lessened the need for formal cost justification of CASE tools. Also, since a belief in automation was already per-

development, maintenance, or project management activities.

But to qualify as a bona fide CASE tool today, a software tool must exhibit additional traits. CASE tools use powerful graphics to describe and document software systems and to enhance the user interface. CASE tools are integrated, making it easy to pass data from tool to tool. And CASE tools capture software system information in a computerized repository where it can be shared among software developers, used as the basis for automating software production, and reused in future software systems.

In the mid-1980s, there were only a handful of CASE tools offered in the marketplace. Today, over 100 vendors sell CASE tools worldwide. While the 1988 worldwide CASE market reached about $250 million, a rapid growth rate of 30 percent to 45 percent per year is predicted to drive the CASE market size to $1 billion by the early 1990s.

Selecting a Tool

With so many different CASE tools from which to choose, selecting the right one for the job requires some consideration. No one tool can provide complete automated support for the development and maintenance of every type of software system. Different CASE tools run on different types of hardware, specialize in the development or maintenance of different types of software systems, and automate different software tasks.

What the tool does is the fundamental selection consideration. CASE tool categories explain and differentiate the functions performed by different types of CASE tools. The two basic categories are toolkits and workbenches.

A CASE toolkit is a collection of integrated software tools that provide auto-

vasive throughout this manufacturing company, Deere management needed little convincing that software automation was the answer to software productivity and quality problems.

Today, Deere & Co. uses CASE tools to free its software developers to be more creative by automating many mundane, repetitive software tasks, such as documentation and code generation. Although CASE tools primarily are used by and benefit professional software developers, Deere hopes that eventually end users will be able to access the CASE tool repository where company data and business operating rules are being stored.

Deere & Co. offers some good advice for CASE users. First, although it knows of several deficiencies in CASE tools today, Deere said that this is no reason to wait to use the CASE technology. In addition, no organization can absorb all of CASE at once. Therefore, it is best to get in and gradually get experience with CASE.

Second, Deere & Co. advises that management "press hard" to ensure that CASE tools are actually used. An important consideration in implementing CASE is a plan for educating users in CASE tool and software development methodology. Finally, Deere suggests that an organization begin by first defining its needs and the benefits it is seeking. Then, it should look for the technology that can address those needs and deliver those benefits.

DuPont

Like Touche-Ross, DuPont of Wilmington, Delaware, entered the business of custom-application system development in part because of CASE. The other element that has made this business move possible is RIPP, DuPont's proprietary software-prototyping technique. In 1988, the Information Engineering Associates (IEA) unit at DuPont began offering custom-application development services for Digital Equipment Corp.'s VAX-based information systems for customers internal and external to DuPont. IEA uses the CASE workbench CorVision from Cortex to support its RIPP prototyping approach to software development.

DuPont's experience with CASE tools and prototyping began in 1985 with the development of the Bulk Continuous-Fiber Tracking System for the Camden-based Textile Fibers department at DuPont. A 6-to-1 productivity increase over estimated performance proved the project a notable success and opened the door for subsequent CASE/RIPP development projects at DuPont.

Over the next 15 months in nine other development projects using the CASE/RIPP approach, DuPont measured success in terms of a $2 million savings. By 1988, over 50 DuPont departments used the CASE approach. Productivity increases ranged from 3-to-1 to 5-to-1 over manual development methods using COBOL or FORTRAN. Application-maintenance costs decreased by as much as 75 percent.

DuPont's advice to CASE technology users underscores the requirement of end-user involvement as a critical factor in ensuring project success. According to DuPont's IEA unit, if key end users are not willing to commit adequate time to the systems development effort, then don't do the project; the risk of failure is too great.

mated assistance for one type of software task; use a common repository for all technical and project management information needed to build and support a software system; share a common user interface; and share a common tool interface. CASE toolkits focus on the support of one phase of software development or one type of software task, such as systems analysis, database design, or program implementation.

A CASE workbench, on the other hand, is a collection of integrated software tools that provide automated assistance for software systems analysis, design, and implementation; share a set of common assumptions about the software process model or methodology being automated; use a common repository containing all technical and project management information needed to build and support a software system; automatically pass software system information from process step to process step; share a common user interface; and share a common tool interface. CASE workbenches offer automated support across the software development process to deliver a documented, executable software system.

Other technical considerations for choosing CASE tools are the hardware platforms on which they run; the type of target system, such as a mainframe-based COBOL information system or an embedded FORTRAN real-time system, that the tools help build and maintain; and the types of structured methodologies, structured diagrams, and error checking that the tools automate. Another important technical consideration is the capability of the CASE tool repository to store and manage various types of software system information. The text box "A CASE Tool Evaluation Checklist" on page 240 can guide you in tool selection.

Nontechnical considerations center on the ability of the vendor to develop and support CASE tools, the training and support needed to introduce them into an organization, and the organization's attitude toward software automation.

CASE Toolkits

Since a CASE toolkit specializes in automating particular software tasks, choosing one involves matching the tool to the tasks to be automated. Also, CASE tool users frequently use several different toolkits as well as outside tools, such as fourth-generation languages, dictionaries, and DBMSes, during the software process. When this is the intent, then how well the toolkits and outside tools can be interfaced to work together is another important tool-selection consideration.

• *Analysis and design*. These toolkits are used to create a software system specification and design. They include screen and report painting, simulation, prototyping, and error-checking functions. Many analysis and design toolkits run on the IBM PC and compatibles; are used to create information systems; and support widely used structured methodologies, such as DeMarco or Gane/Sarson structured analysis, Yourdon or Jackson structured design, and Martin information engineering.

Examples include The Developer from ASYST Technologies, Design Generator from Computer Sciences, POSE from Computer Systems Advisers, Pro-Kit*Workbench from McDonnell-Douglas, Excelerator from Index Technology, DesignAid from Nastec, Design Machine from Optima, MicroStep from Syscorp International, Structured Architect from Meta Systems, vsDesigner from Visual Software, and Analyst/Designer Toolkit from Yourdon. (Contact information for the products discussed in this

continued

article is provided in the resource guide "A CASE Workshop" on page 246.)

Other analysis and design toolkits used in the development of information systems, such as AnaTool from Advanced Logical Software, run on the Macintosh, while still others, such as CA-Universe/Prototype from Computer Associates International and CasePac from On-Line Software International, run on IBM mainframe computers.

CASE analysis and design toolkits that support the development of real-time or embedded systems, real-time structured methodologies (such as Ward/Mellor and Hatley), Ada program development, and DOD2167 documentation generation frequently run on 32-bit engineering workstations, such as Sun, Apollo, Hewlett-Packard, or DEC VAXstations. Examples include Teamwork from Cadre Technologies, Software Through Pictures from Interactive Development Environments, StateMate from i-Logix, Analyst/RT from Mentor Graphics, System Architect from Popkin Software & Systems, CardTools from Ready Systems, and SDT from Telelogic Europe.

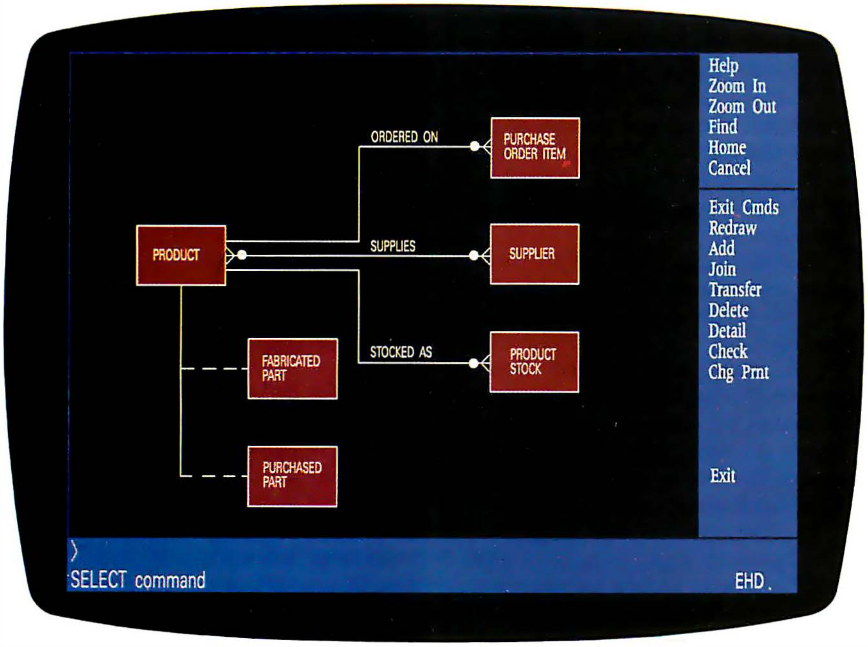


Figure 1: *The IBM PC screen view of an entity-relationship diagram drawn with the Information Engineering Facility from Texas Instruments.*

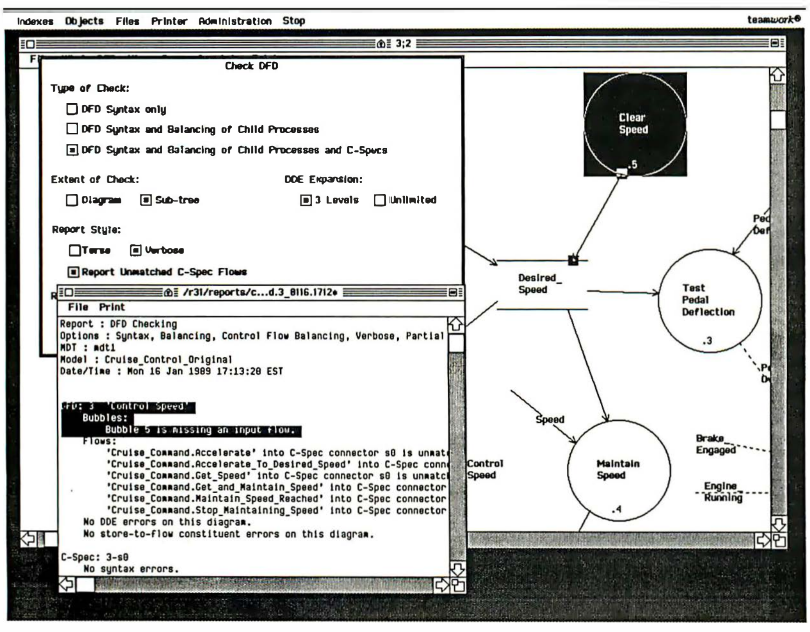


Figure 2: *Teamwork from Cadre Technologies reports syntax, balancing, and missing information errors in data-flow and control-flow diagrams.*

• *Database and file design.* These toolkits provide automated assistance for the design of databases and files by performing functions such as logical data modeling, conversion to third normal form, and generation of database schemas and program-code file descriptions. Examples of database and file-design toolkits that run on IBM PCs and compatibles include IDEF/Leverage from D. Appleton, Chen Toolkit from Chen & Associates, IDMS/Architect from Cullinet Software, 4Front from Deloitte, Haskins & Sells, Auto-Mate Plus from LBMS, and CASE*Designer from Oracle.

• *Programming.* These toolkits support the programming and testing steps in software development. Programming toolkits that provide configuration management functions on the IBM PC or DEC VAX include P-Source and P-Tools from Phoenix Technologies and PolyMake from Polytron. CoFac from Coding Factory and COBOL 2/Workbench from Micro Focus provide support for the creation of COBOL programs and run on the IBM PC.

Other programming toolkits provide automatic code generation from program-design specification information. These toolkits, called code generators, automatically produce a fully documented, executable program. They offer screen and report painting, prototyping, custom-logic handling, testing and debugging, and code, database, and documentation generation. COBOL code generators that run on an IBM PC and IBM mainframe or DEC VAX computers include DECASE from DEC, NETRON/CAP from Netron, Telon from Pansophic Systems, APS from Sage Software, and Transform from Transform Logic.

• *Maintenance and reengineering.* This type of toolkit aims the CASE technology at existing software systems rather than at the creation of new systems. Tools in the maintenance and reengineering toolkit, such as documenters, program analyzers, restructuring en-

gines, and reverse-engineering tools, automate a variety of program maintenance tasks and have the potential to improve the maintainability of billions of lines of existing code.

Running on IBM mainframes, IBM PCs, and Honeywell, Unisys, or Wang computers, toolkits such as Adpac CASE Tools from Adpac, Scan/COBOL and SuperStructure from Computer Data Systems, Inspector and Recoder from Language Technology, PathVu and Retrofit from Peat Marwick Advanced Technology, and Via/Insight and Via/SmarTest from ViaSoft provide maintenance support for existing COBOL programs. The Bachman Re-Engineering Product Set from Bachman Information Systems provides reverse-engineering support for IMS, IDMS, and DB2 databases and runs on the IBM PS/2s.

• *Framework.* This kind of toolkit provides a platform for CASE tool integration, creation, and customization. Multi/CAM from AGS Management Systems, Life Cycle Productivity System from American Management Systems, Software BackPlane from Atherton Technology, and Sylva Foundry from Cadware are examples of framework toolkits running on the Sun, Apollo, Hewlett-Packard, DEC VAX, IBM PC, and mainframe computers.

• *Project management.* These toolkits support the planning, controlling, managing, and reporting functions needed for software development and maintenance projects. One example of an IBM PC-based project management toolkit is Project Workbench from Applied Business Technology.

CASE Workbenches

Selecting a CASE workbench involves matching hardware, development methodologies, and target systems that the workbench supports to the CASE user's development style and target-system requirements. For example, IBM PC- and mainframe-based workbenches, such as Foundation from Andersen Consulting, Information Engineering Workbench from KnowledgeWare, PACBase from CGI Systems, CorVision from Cortex, Manager Family from Manager Software Products, Maestro from Softlab, and Information Engineering Facility from Texas Instruments are used to develop information systems that run on PCs or mainframes.

For the development of real-time and embedded systems in languages such as Ada, Pascal, FORTRAN, and C, workbenches such as SuperCASE from Advanced Technology International, AutoCode from Integrated Systems, ProMod from ProMod, and EPOS from SPS Software Products & Services are used.

State of the Practice

The promise of CASE is to increase software productivity and improve software quality. For Touche-Ross, Deere & Co., and DuPont, CASE is fulfilling its promise. Many other organizations, such as Amoco, First National Bank of Chicago, First Boston, Union Pacific, Lincoln National Corp., and American International Group, are also believers in and seasoned users of CASE. Their valuable

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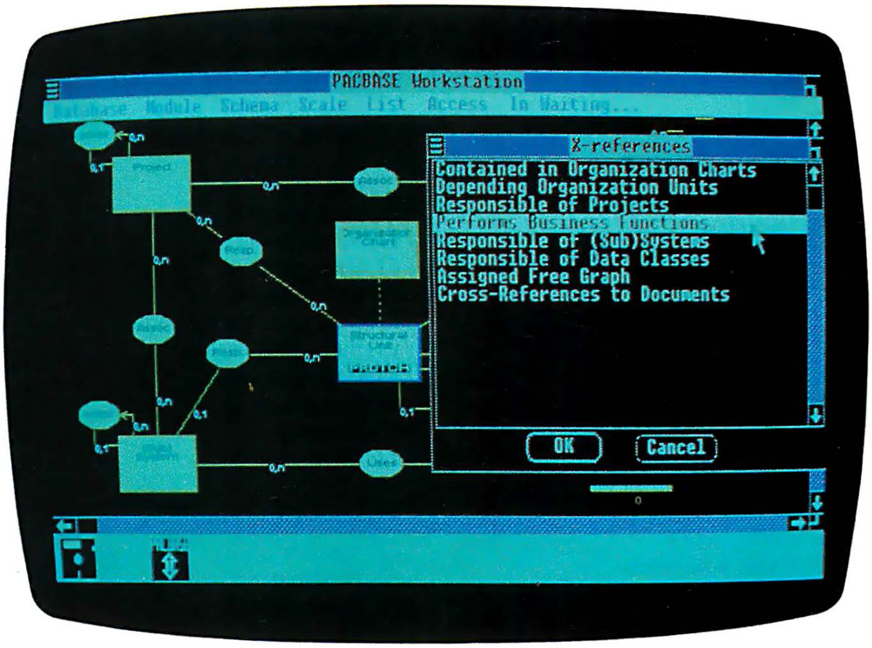


Figure 3: *The IBM PC screen shows PACDesign, part of the PACBase workbench from CGI Systems, which is used during the program-design process.*

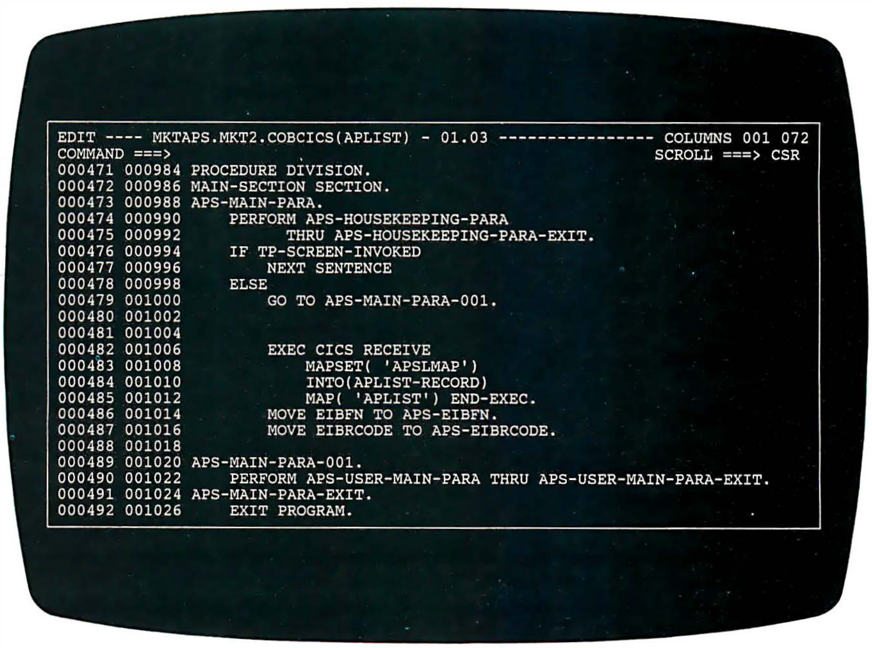


Figure 4: *This COBOL code was automatically generated by APS, the CASE COBOL code generator from Sage Software.*

A CASE Tool Evaluation Checklist

Use this checklist as a guide through the maze of CASE tool options

General information

- ☐ Vendor name
- ☐ Product name
- ☐ Date introduced
- ☐ Number of copies sold
- ☐ Price

Hardware platform

- ☐ IBM PC and compatibles
- ☐ Macintosh
- ☐ Digital Equipment Corp.
- ☐ Unisys
- ☐ Honeywell
- ☐ Wang
- ☐ Apollo
- ☐ Sun
- ☐ Hewlett-Packard
- ☐ Other

Category

- ☐ CASE toolkit
- ☐ CASE workbench

Type of toolkit

- ☐ Planning
- ☐ Analysis
- ☐ Design
- ☐ Database design
- ☐ Real-time design
- ☐ Code generator
- ☐ Programming
- ☐ Maintenance
- ☐ Framework
- ☐ Project management

Graphics

- ☐ Color
- ☐ Mouse
- ☐ Windows

Error checking

- ☐ Syntax
- ☐ Consistency
- ☐ Completeness
- ☐ Requirements traceability
- ☐ Quality assurance

Diagramming support

- ☐ Data flow
- ☐ Control flow
- ☐ Decision table/matrix
- ☐ Hierarchical tree structure
- ☐ Structure chart
- ☐ Action
- ☐ Warnier/Orr
- ☐ State transition
- ☐ Pseudocode
- ☐ Screen layout
- ☐ Dialogue flow
- ☐ Report layout
- ☐ Data structure
- ☐ Entity relationship
- ☐ Logical records
- ☐ Booch
- ☐ Petri nets
- ☐ Other

Methodology support

- ☐ Yourdon
- ☐ DeMarco
- ☐ Gane/Sarson
- ☐ Bachman
- ☐ Chen
- ☐ Martin
- ☐ Merise
- ☐ Orr
- ☐ Jackson
- ☐ Ward/Mellor
- ☐ Hatley
- ☐ Object-oriented
- ☐ SADT
- ☐ Stradis
- ☐ Method-1
- ☐ LSDM
- ☐ Other

Other requirements

- ☐ ______________
- ☐ ______________
- ☐ ______________

CASE repository

- ☐ Host-based
- ☐ PC-based
- ☐ DBMS architecture
- ☐ Reports
- ☐ Change control
- ☐ Audit trail
- ☐ Version control
- ☐ Download
- ☐ Logical partitioning
- ☐ Consolidation

Prototyping support

- ☐ Screen painter
- ☐ Report painter
- ☐ Functional model
- ☐ Simulation

Code generation

- ☐ Skeleton program
- ☐ Complete program
- ☐ Language
- ☐ On-line program
- ☐ Batch program

Reengineering support

- ☐ Static analyzer
- ☐ Redocumentation
- ☐ Restructure
- ☐ Reverse engineering
- ☐ Dynamic analyzer
- ☐ Converter

Life-cycle support

- ☐ Planning
- ☐ Analysis
- ☐ Design
- ☐ Implementation
- ☐ Maintenance
- ☐ Project management

Target system

- ☐ On-line
- ☐ Batch
- ☐ Transaction processing
- ☐ Real-time
- ☐ Embedded

experiences and insights can guide others in wisely selecting CASE tools and successfully implementing the CASE technology. The following summarizes their experiences and consensus about the current state-of-the-practice of CASE technology.

• *Profile of a user.* First, regardless of which tools they use, the primary users of CASE tools today are professional software developers (e.g., business analysts, systems analysts, programmers), not the end users. This is not meant to

continued

suggest that end users are being shut out of the software development process. On the contrary, end-user involvement in the form of interviews, reviews, and use of software prototype models is critical to software project success.

Users point out that although CASE tools are user-friendly, the quantity of system information that they must enter into the tool demands too much of their time. Moreover, using a CASE tool requires a level of software development knowledge that is beyond that of many end users. Even for the professional software developer, substantial training and experience are needed to effectively use CASE.

CASE tool training is not as significant in terms of time and cost as methodology training, which can be as much as three times as expensive. The amount of training required depends on whether developers have already been trained in the methodology to be supported and automated. Furthermore, attitude can have just as much influence on the effective use of CASE as training. Users agree that enthusiasm is a must to ensure successful results from CASE.

• *Management support.* It is extremely difficult to cost-justify bringing CASE into an organization, because most companies have no measures for software productivity or quality and no historical software-project data. While the desire is to do "better," there is no universally agreed-on way to quantify what "better" means.

For many CASE users, the only way to get management commitment is to convince management to give CASE a try on blind faith. Also, many users note that the real payoff doesn't occur during systems development but later, during system maintenance and with the leverage from reusing data models and other system information stored in the CASE repository. Some users report that the maintenance of systems developed with CASE requires only 20 percent of the effort needed to maintain those systems developed with traditional techniques.

• *Changing software development.* Opinions are divided on whether CASE changes software development and maintenance. Those who think CASE doesn't significantly change software development are using CASE tools to automate a methodology they have used previously. The software process remains basically the same but is streamlined by automating some labor-intensive tasks.

On the other side, users who say CASE dramatically changes the way they develop systems are bringing in a new software development methodology along with CASE tools. For example, they may have moved from a process-driven development approach to a data-driven approach, or from a traditional waterfall life-cycle model to prototyping.

According to one CASE user, the nature of maintenance work has changed. Instead of maintaining code, users are now maintaining design specifications and, in particular, a data model. Keeping the data model up-to-date has become a top-priority maintenance task. One trend appears to be toward adopting data-driven methods and prototyping techniques as standard information-systems development strategies.

• *Single or multiple CASE vendors.* Users are also split in their strategy to

continued

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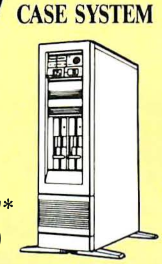
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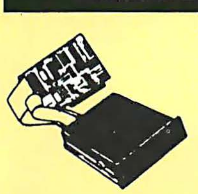
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use tools provided by only one vendor or multiple CASE product vendors. Users dedicated to a single-vendor approach believe a single vendor can provide a higher level of tool integration.

On the other hand, users who mix and match tools from multiple vendors say they want the best tool for each task and that different vendors excel in different areas. And since these users develop systems for different target environments, different tools are often necessary.

Users are confident that as industry standards emerge, CASE tool interfaces will be improved. At the very least, most CASE users experiment with multiple CASE tools regardless of whether they intend to follow a single- or multiple-vendor strategy.

Start Now

Organizations considering CASE should start now and start slowly. Start now because you need some experience with CASE before you can derive significant benefits from it. The learning curve can be steep, especially when you start by introducing both new CASE tools and new methodologies. Starting slowly gives you the opportunity to experiment with new tools and/or new methodologies before embracing CASE on a wide scale.

Most CASE experiences originate in various types of R&D groups whose charter is to find better ways to develop software systems. Many organizations are interested primarily in increasing productivity, while others are searching for ways to get organized, especially from the data perspective, and some are simply researching future technologies. However, regardless of what they were expecting from CASE, those organizations that reported achieving their goals all began their CASE experience with two major advantages: They were advocates of change, and they had management support.

If you are new to CASE, think about what your organization hopes to achieve and then select the tools that can help achieve those goals. Begin the CASE experience with a pilot project in which there is no pressure, no immediate productivity goal, and lots of management support. And, by all means, begin now. ■

Carma McClure is vice president of Extended Intelligence in Chicago and has a Ph.D. in computer science from the Illinois Institute of Technology. A leading authority on CASE, her most recent book is CASE Is Software Automation *(Prentice-Hall, 1988). She can be reached on BIX c/o "editors."*

A CASE Workshop

Compiled by Carma McClure

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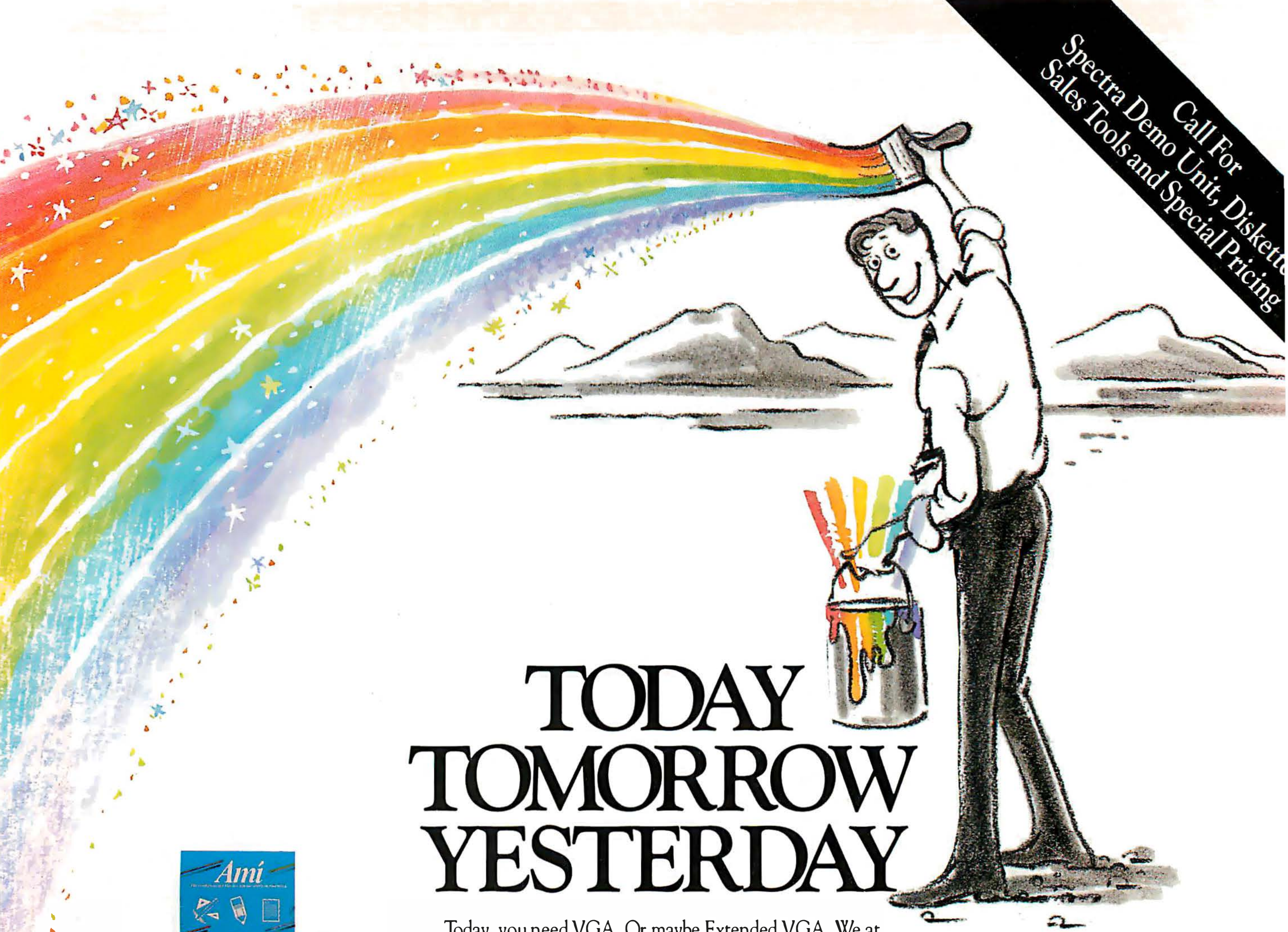
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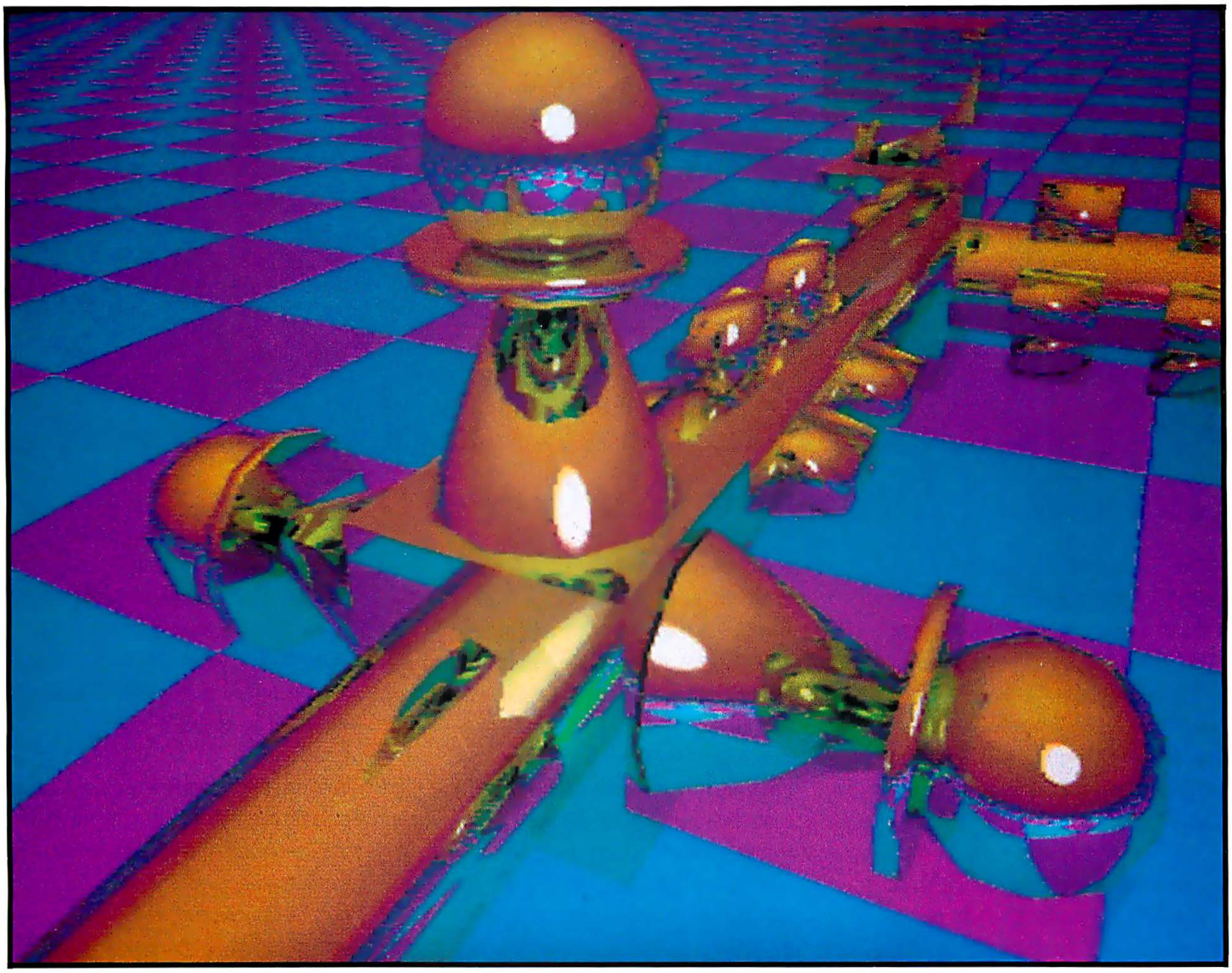
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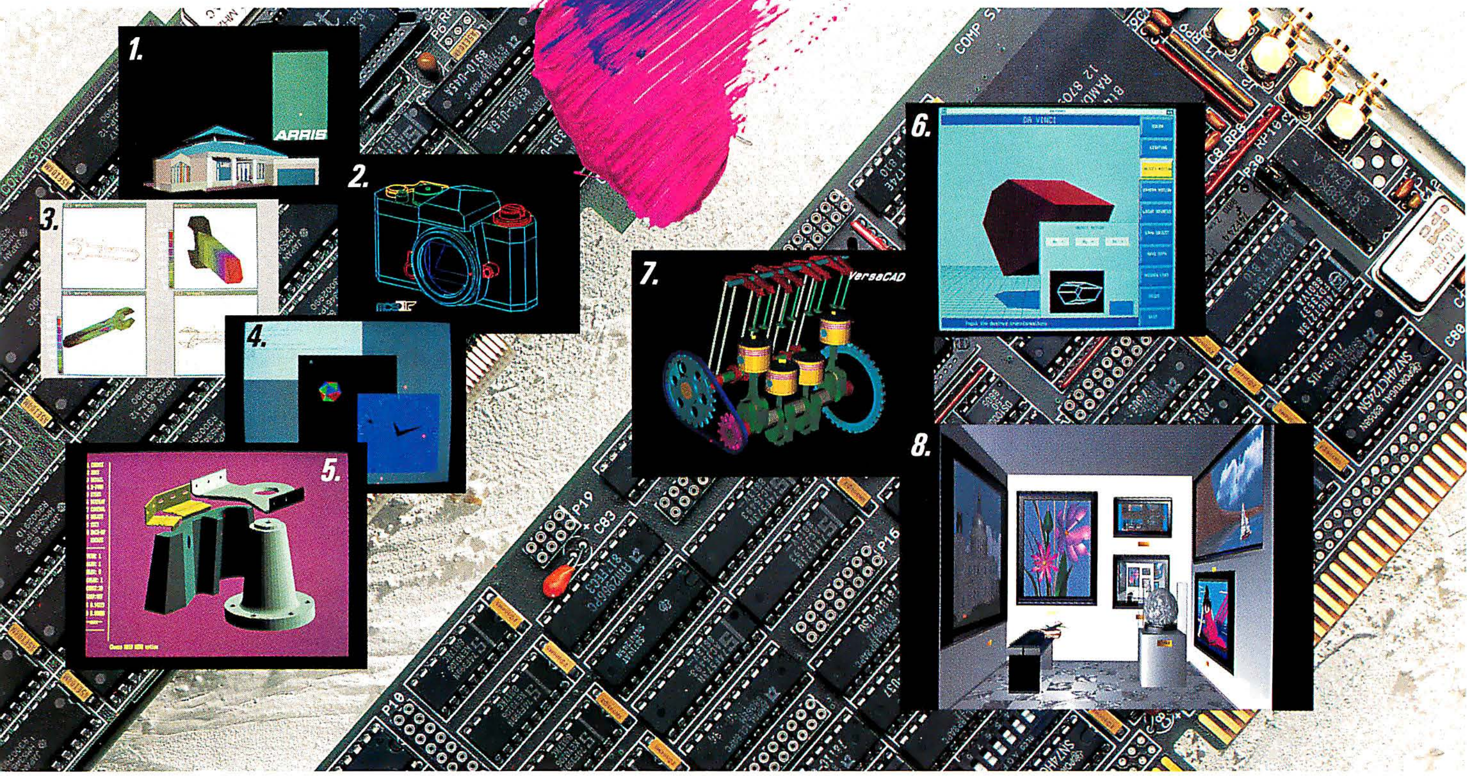
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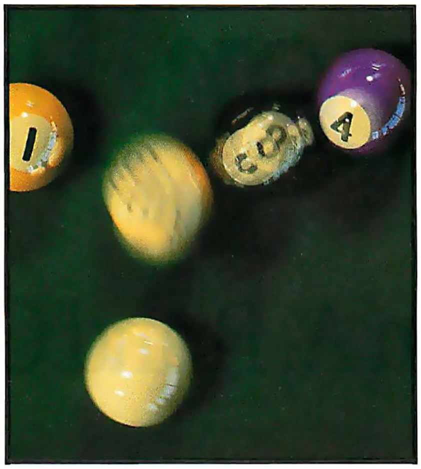
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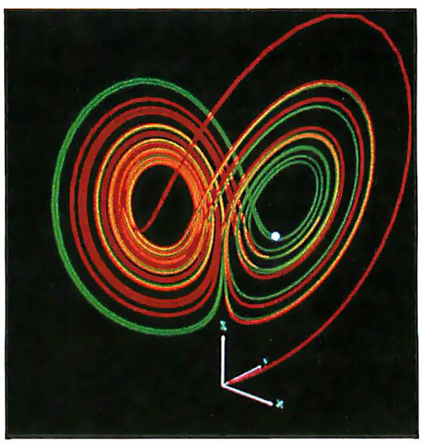
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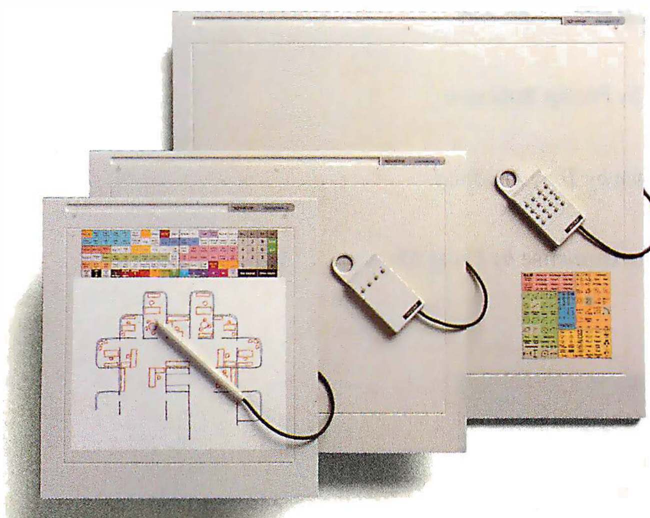




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Variations on a Screen

Phillip Robinson

What are the peculiarities of IBM PS/2, Macintosh, and Amiga graphics hardware?

Graphics used to be an afterthought on computers, an unnecessary frill. There were a few "graphics computers" with special hardware for drawing lines on a screen, but these were expensive machines aimed at narrow niches. The only graphics the early personal computers could boast was the ability to draw characters on a screen in neat rows and columns. That was OK for word processing, spreadsheets, and databases.

With some arm-wrestling, text displays could even produce simple drawings or game figures (using combinations of characters to represent objects and fill patterns). But only home computers that doubled as "game machines," such as the Commodore 64, Apple II, and Atari 800, had special hardware to automate such graphics operations as moving a colored shape from one part of the screen to another or determining when a particular shape was touching another shape on a display.

When the IBM PC came along, text mode was seen as the proper province for most business programs. The PC didn't even have its own text abilities built in but took its graphics cues from whatever "display adapter" circuit board you plugged into it. As the applications for PCs, and then for the closely related PS/2s, expanded to include drawing, charting, and presentation tasks, the display adapters added pure graphics modes with more and more colors and resolution.

The machines in the PS/2 line came with a built-in display adapter. A number of other companies developed display adapters that would work in PCs and compatible systems—adapters that might pack special "modes" with far more resolution and color ability than any offered by IBM. To use these adapters, however, you needed special driver software that was usually available only for a few big-name programs (e.g., AutoCAD, PageMaker, and Ventura Publisher). Some programs were even able to work with two display adapters at once, which was useful, for example, in showing a CAD program menu on one monitor while the drawn image appeared on the other.

Then the Macintosh appeared, and it didn't even bother with a text mode for display. Everything was graphics, including the interface itself—used with every program—of icons, windows, and graphical cursors. Even writing text to the screen was a graphical act. For all this, the Mac had its own built-in video monitor, hardware, and firmware.

As the Macintosh line has evolved to the Mac II and IIx, this basic setup has persisted, although the monitor has been separated from the bundle, the software now provides color, and the graphics can be enhanced with plug-in display adapters. The Macintosh operating system can automatically handle up to six different monitors simultaneously. Because every Mac comes with a mouse for pointing at particular coordinates on the monitor, there is a standard set of commands for manipulating most Macintosh graphics programs. The PS/2 world has not become as settled as that for graphics input.

The Commodore Amiga goes a step beyond the PS/2s and the Mac in graphics hardware, borrowing and building on the special games circuits from the Atari and Commodore 64 era. Besides a graphical interface and firmware routines for graphics, the Amiga has custom ICs that can speed graphics programs. What's more, those same chips provide games and animation features for the Amiga and give it an inside track for working with television signals. That makes it a natural for "desktop video" work.

In the rest of this article, I'll talk about the graphics hardware behind the PS/2s, Mac, and Amiga, go over a little history, describe how each works, and discuss their strengths and weaknesses. (The text box "Display and Video Buffer Fundamentals" on page 260 provides a general overview of the graphical environment common to the three systems.)

PS/2s

The PS/2s' graphics capability evolved directly from the IBM PC's graphics, so it is useful to first take a look back. The original PC, XT, and AT had no built-in graphics hardware. You bought a monitor and a video adapter board to go along with your PC. The board and the monitor were connected with a nine-wire cable. Programs had to be written to understand the various adapters to take advantage of their resolution and color.

IBM's Monochrome Display Adapter (MDA) could produce 80 columns by 25 rows of text and character-size symbols. CGA could do the same in color on an RGB display. CGA could also produce graphics, a pixel at a time, and it had a port for a composite video signal to feed to a TV set. (That composite ability, common in early personal computers, has fallen out of favor because TVs don't offer high-enough frequencies and resolutions for today's software.)

MDA's highest resolution was 720 by 350 pixels. Individual characters were formed in sets of pixels 14 high by 9 wide. CGA could manage only 640 by 200, and so made its same 80 columns and 25 rows of characters in sets of pixels 8 high by 8 wide. With nearly twice as

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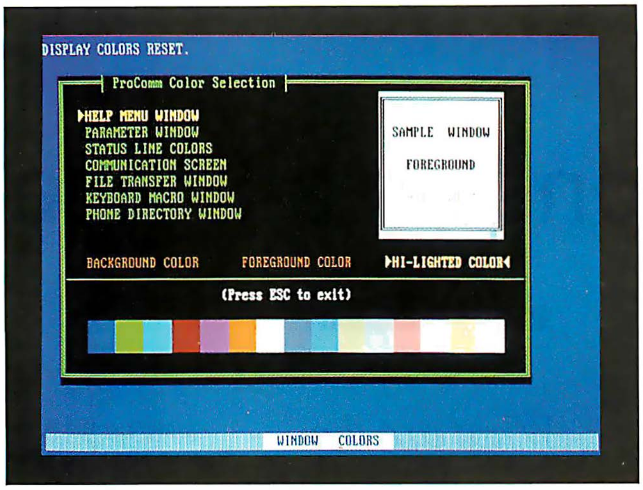


Photo 1: *The PS/2s' graphics capabilities evolved from the IBM PC's character-oriented displays but are now more flexible and updated and have higher resolution.*

many pixels to work with, the MDA characters were much easier to read. CGA characters were at the bottom end of legibility. (Older personal computer systems with lower resolution often achieved legibility by compromising on the number of columns and rows displayed on the monitor. Take the same 640 by 200 resolution of CGA and break it into 40 columns by 20 rows, and you can make characters with several times the precision of the 80-column by 25-row standard. However, 80 columns does a good job of matching the number of characters that can fit on a standard typewritten page, so fewer columns can lead to lots of horizontal scrolling to see everything that will print on a page.)

Hercules was one of the few companies to independently establish a hardware standard in the world of IBM PC and compatible computers, with its Hercules Graphics Card (HGC). This video adapter with a resolution of 720 by 348 pixels in monochrome could handle MDA software (i.e., was MDA-compatible) and could produce pixel-by-pixel graphics in monochrome. The HGC Plus could work with RAM-based characters instead of the ROM-based characters that the MDA and HGC were designed to control. The Hercules InColor card added 16-color display (from a palette of 64) to the abilities of the HGC Plus.

The final step in popular PC graphics was EGA from IBM. (There were also adapters, such as the Professional Graphics Adapter [PGA], with higher resolution than the EGA, but they were expensive and never acquired a large body of compatible software.) EGA can run MDA or CGA graphics and was the first IBM adapter that could produce pixel-by-pixel graphics in monochrome. Its top resolution was 640 by 350 pixels, and it could put out 16 colors.

The more advanced cards offered a variety of modes with different resolutions and color abilities. While HGC had a single mode, CGA, for instance, had two graphics modes: 320- by 200-pixel four-color and 640- by 200-pixel monochrome. Software chose which mode to use and could switch from mode to mode depending on a program's needs. EGA had more than a dozen modes with various resolutions and specifications. Competing, compatible "super-EGA" cards offered special modes with yet more resolution. Some boards, such as the Truevision Targa series, provided a much larger color palette—a necessity for desktop video work.

The poor PC programmer had to write drivers for each possible adapter.

The poor PC programmer had to write different drivers for each adapter the user might have and had to know about all these modes and resolutions. On MDA, CGA, and HGC, a Motorola 6845 video controller chip set the timing and other details of the video signal, and that's the chip programmers wrote directly to if they wanted to bypass the "famous" BIOS INT 10H (Interrupt 10h) for video routines or if they had an HGC (which the BIOS didn't recognize and thus required direct programming).

EGA had its own proprietary controller chip. Companies that wanted to copy the EGA board had to create chips that were compatible with that special controller. The CGA board, incidentally, is famous for the "snow" or white specks it sometimes creates on a display if the program is trying to write directly to the video buffer. That direct work interferes somewhat with the information read and sent to the monitor. Another fascinating fact about programming the Motorola 6845 is that it represents one of the few places in computer programming where software can actually hurt the hardware. Use timing values that are too foreign to the monitor, and you could permanently damage parts of that monitor.

Not all monitors work with all video adapters. The higher frequencies of the EGA modes are beyond the abilities of some CGA-, HGC-, and MDA-capable monitors. The CGA and EGA boards can be run side by side with an MDA board, producing two outputs (one text and one graphics) from the same PC or PS/2.

The PS/2 line came with a pair of new, built-in display adapters. The Multi-Color Graphics Array (MCGA) on Models 25 and 30 works like CGA with greater resolution: 640 by 480 pixels, tops. VGA, found on all the other PS/2 machines, is a single chip that can handle all the EGA modes (although some programs need slight rewriting for compatibility) and has some new modes of its own. These include 720- by 400-pixel text and 640 by 480 pixel-by-pixel graphics. You can now also buy VGA-compatible display adapters for PCs, XTs, ATs, and compatibles. There are even super-VGA cards with modes that sport greater resolution than VGA's standard set.

Yet another new display adapter was announced along with the PS/2 line: the 8514/A graphics adapter. This separate board plugs into a special auxiliary video connector slot in the PS/2 models with the Micro Channel bus (i.e., Models 60, 70, and 80). It substitutes its own signals for those coming from the main board's VGA circuitry and can produce 1024- by 768-pixel resolution on an 8514A-capable monitor. With enough memory, an 8514/A board can also generate 256 colors from a palette of 256,000. At its 640- by 480-pixel resolution, the 8514/A can automate a few graphics tasks, such as programmable fonts and filling areas. The 8514/A may eventually replace VGA as the standard in PS/2 graphics, but it hasn't been very popular yet, perhaps because of the relatively high cost of the special board and monitor.

Both MCGA (which appears only on

continued

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PS/2 Models 25 and 30) and VGA (which is now being cloned by other firms and has become the PS/2 and PC standard video adapter) produce analog signals to tell a monitor what colors to display. They have D/A converter circuitry that turns the bits from the video buffer into analog waves on the lines to the monitor. MDA, CGA, HGC, and EGA all produce digital RGB output, with lines that signal either on or off for a certain color value. Analog output offers much larger color selections but must drive a monitor that understands analog information. Most monitors used with PCs, XTs, and ATs are digital and cannot move to the VGA level. Some monitors handle analog or digital. The MCGA and VGA formats can each produce 256 colors from a palette of 256,000, connecting to the monitor through a 15-pin cable.

The PC running conventional DOS doesn't use the same RAM for video as it does for programs and data. An area above the 640K-byte limit, well known to PC and PS/2 users running DOS, and below the 1-megabyte addressing limit of the 8086 processor is dedicated to video. The size and address of the buffer depend on the particular display adapter, although all are between A0000 and C0000 (a 128K-byte area above 640K bytes). The memory chips for this are actually on the display adapter card, not on the main system board.

The information in the video buffer produces character codes (for text mode) or attributes (for bit-mapped mode) that are sent to an alphanumeric character generator or an attribute decoder. The information from these circuits is combined with the mode settings from the program and the timing information from the CRT controller to produce a video signal appropriate for the monitor.

The PC and PS/2s have no special hardware to help the CPU get the bits into the video buffer and no graphics accelerators or dedicated graphics function circuits. There are a few logical operations in the controller chips, but PS/2 graphics is mostly a matter of learning BIOS calls and collecting controller assembly-language routines. This makes the PS/2 line quite flexible for software jockeys who have studied the hardware's basics, but not well suited for animation or other complex software tasks. And with its text modes, it can run simple, non-WYSIWYG, text-based applications—spreadsheets, word processors, databases—faster than the Mac or the Amiga.

Macintosh

The IBM PC began life without graphics, adding it through plug-in boards. The Mac was born with a built-in monitor, a built-in video adapter, and a large set of built-in graphics routines in system software ROM. The Mac's software is its most unique element—and its ability to show on the screen pretty much what you'll see in print is a big selling point. That software includes QuickDraw (a set of drawing routines for basic objects), a Font Manager (that uses QuickDraw to draw text characters on the screen), and a Window Manager (to draw and control windows on the screen that contain programs or file listings).

The Mac ROM has grown from an original 64K bytes of routines to a full 256K-byte ROM in the Mac SE and II. The newer ROMs include faster versions of the older routines and new software to provide color support, fractional-pixel-

VARIATIONS ON A SCREEN

width characters, and so on. Above this ROM is an operating system that handles I/O and the Finder, a program that tracks directories and other disk operations.

The early Macs (including the Mac Plus and SE—or the Integral Video Macs, as Apple puts it) have a built-in, 9-inch diagonal monochrome monitor. The built-in video adapter offers one resolution: 512 by 342 pixels in monochrome. That works out to 72 dots per inch on the screen, the same as on the original ImageWriter dot-matrix printer that Apple sold for use with the Mac. It's also about the same as the 1/72-inch measurement in typography known as a *point*. (Later Apple would turn to the LaserWriter laser printer, with its resolution of 300 dpi, and use the drawing routines of PostScript to drive the higher-resolution printer while QuickDraw was still handling the monitor.)

On the Mac Plus and SE, the video buffer is formed in part of the standard system RAM, taking up 21K bytes. Both the Mac Plus and SE have two screen buffers: a main and an alternate. The display can be switched from one to the other with a quick change of a single value in the controller—a useful procedure for animation. (On the Mac Plus and SE, each pixel is either on or off: Gray-scale effects come from combining groups of pixels into logical units and turning on or off a percentage of the pixels in each group to create intensity levels.)

Application and system software make any changes to the bit-map image in RAM. On the Mac Plus and SE, a video controller on the main circuit board then shuttles the video buffer information to the monitor. It is possible to plug a color monitor into the Mac SE, but its ROM does not contain full QuickDraw support for color. That means that you must de-

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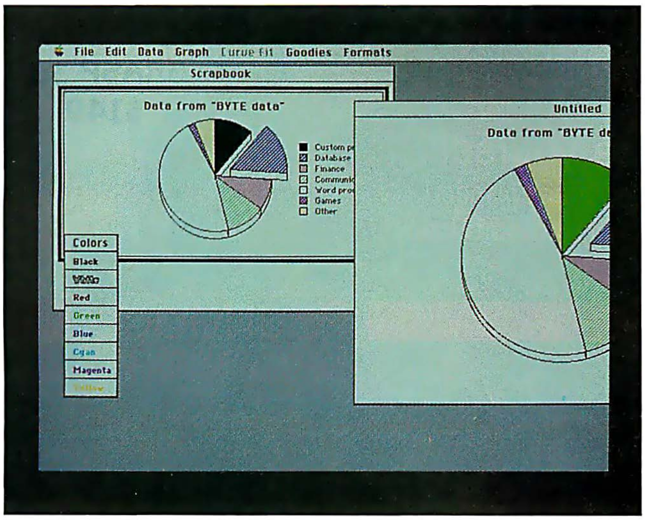


Photo 2: *The Macintosh began life as a graphics-oriented machine—even the text is graphics—and has grown in sophistication with each succeeding generation.*

pend on special software drivers for color in each program.

The Mac II and IIx can drive any of a variety of monitors, operating from plug-in video adapter boards much as a PC would. A board can also carry special processors, ROMs, and video RAM. The Mac II ROM supports color in QuickDraw. However, that support is only for 8 bits of color information per pixel, or a total of 256 possible simultaneous colors (from a palette of 16.7 million). You can also choose to work with 2, 4, or 16 colors or gray levels.

Apple's own video card puts out either 640 by 480 pixels monochrome (with up to 16 intensity levels) on Apple's 12-inch monochrome monitor or, with enough on-board RAM, 640- by 480-pixel resolution in 256 colors or gray levels on Apple's 13-inch color monitor. The vertical scan frequency is 60 Hz, noninterlaced. That leaves it outside the realm of standard TV signals, so Macintosh graphics cannot be directly recorded on standard VCRs. Nor can you use typical TVs or PC monitors with the Mac II because it, too, has a noninterlaced (480-line) display.

Some firms make 24-bit video adapters for the Mac that can display as many colors simultaneously as there are pixels on the screen. Unfortunately, these cards need special software drivers to take advantage of the full range of colors: Apple's system software and ROM have not yet come to support this "full color" and provide it to all programs, but this may happen this year or in 1990.

Most of the competing monitors are larger than Apple's. Some of them offer the same or nearly the same number of pixels as the Mac Plus and SE, but on a larger screen, and so have fewer dots per inch. Others have the same or greater dpi counts than the Mac Plus and SE, and so put many more pixels onto the larger screen. Resolutions range from that original 512 by 342 pixels to as high as 1664 by 1200 pixels. (Remember, however, that 1200 lines on a screen 24 inches tall do not make characters and objects more precise than 400 lines on a screen 8 inches tall. Both screens have the same dots per inch, but the larger monitor can hold more of a large image or more images at the same time.)

The Mac's operating system can run multiple monitors at the same time and offers a utility for selecting which one has the main menu bar and how the monitors are logically positioned with respect to each other (i.e., how the cursor moves from one to another). The monitors may come with extra software that adds special zooming or other view-control features.

The Mac does not have any special hardware for graphics acceleration or automation. What it does have is a well-crafted and refined set of system routines stored in a large ROM—routines for creating, organizing, and tracking graphics on the screen, including windows, drawn graphics, imported pictures, and just about anytning else.

All the actual figuring and data movement are handled by the main processor: the 68000 chip in the Mac Plus and SE, the 68020 in the Mac II, and the 68030 in the Mac IIx. The increased main processor speed of the Mac II's 68020 and the Mac IIx's 68030, as well as the built-in floating-point math coprocessor, directly contribute to graphics speed because the CPU/FPU pair does all the graphics calculation work.

Having a graphical interface to a program is easier on the Mac than on the PC,

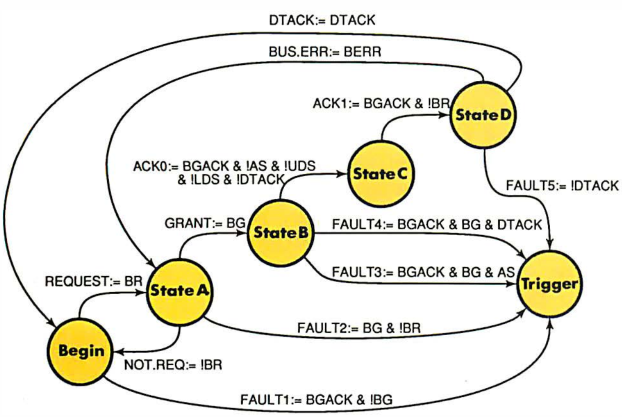
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Total Channels	32	32	32	32
Max Timing Rate	100 Mhz	100 Mhz	100 Mhz	100 Mhz
# Channels @ Max Rate	16	16	8	8
Max State change Rate	25 Mhz	16.6 Mhz	12.5 Mhz	10.0 Mhz
Max State Clock	50	25	25	25
Data Storage (per chan)	4K	1K	1K	2K
Storage Method	Linear	Transitional	Linear	Linear
Trig Method	Multi-Way Branch & Loop	Linear Sequential	Linear Sequential	Linear Sequential
Number of Match Regs	28	8	8	8

* Based on published specifications



Trigger program to detect 1 of 5 possible faults in the DMA cycle of a MC68000. This example uses only a fraction of the capabilities of the Pc/La.

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The Mac's operating system can run several monitors at the same time.

where Windows, GEM, or the Presentation Manager (programs that give a "Mac look" to a PC) labor without the help of tailored firmware routines. However, simple programs that stick to text mode are nearly always faster on a PC. Although the Mac began as a monochrome machine, the Mac II already provides richer color than the VGA standard on the PC (with the same number of colors from a larger palette) and will move even farther ahead when the system software supports full color.

Amiga

Commodore's Amiga can be seen as either the next step in graphics hardware beyond the Mac (and two steps beyond the PS/2 line) or as an amalgam of the general-purpose graphics ofthe Mac and the special-purpose graphics of earlier game computers from Atari and Commodore. From the original Amiga 1000 to the less expensive and less expandable Amiga 500 and the higher-powered 2000, the Amigas begin with a 68000 central processor just like the Mac's. The Amiga 2500 adds a 68020 processor board to a 2000 frame, increasing the main processing speed.

All Amigas use the same graphics strategy. Instead of leaving the 68000 CPU to handle all the graphics calculations along with its other chores (the Mac strategy), the Amiga has a trio of custom ICs dedicated to processing graphics information. Because these chips can handle video information while the main CPU is working on other tasks, the Amiga has a degree of "multitasking"—the ability to handle more than one job at a time. On top of this graphics hardware, the Amiga has a choice of user interfaces: Intuition with the Workbench (which looks like the Mac's graphical interface with the Finder), or the CLI (Command Line Interpreter, which looks like the DOS text interface).

The three custom chips have names: Denise, Agnus, and Paula. Denise handles the display chores, acting as the CRT controller. Agnus has hardware to automate animation work such as special registers to maintain and propel *sprites,* which are object-oriented groups of pixels. Paula handles a variety of sound and disk drive work, besides providing for the fast direct-memory-access movement of information within the computer. DMA transfers don't tie up the main processor, leaving it free to work and speeding the data transfer. And Agnus contains a coprocessor, nicknamed "Copper," for accelerating graphics work, and a "Blitter" for hardware bit-block transfer operations such as line drawing and color fills.

Unlike the PS/2s and the Mac, the Amiga is quite flexible when it comes to choosing a monitor. In fact, it has ports for RGB monitors, composite monitors, and standard TV sets. It can even drive all three at the same time because each port constantly provides the same display information, each in its particular format. The RGB monitor port provides analog signals, though it can be adapted to

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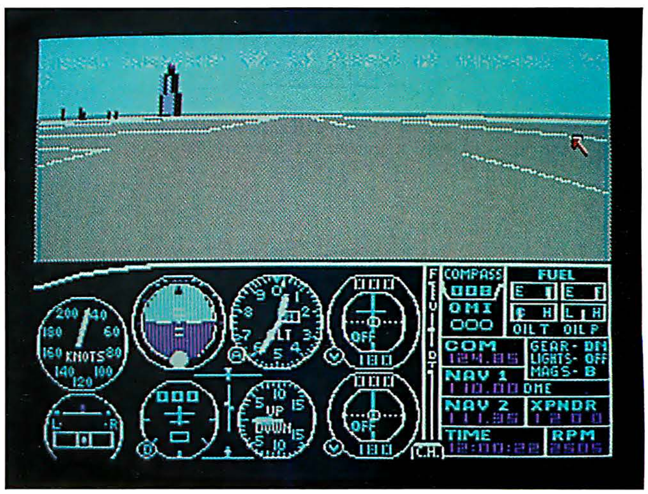


Photo 3: *The Amiga can be seen as an amalgam of the general-purpose graphics of the Mac and the special-purpose graphics of early Commodore and Atari game computers.*

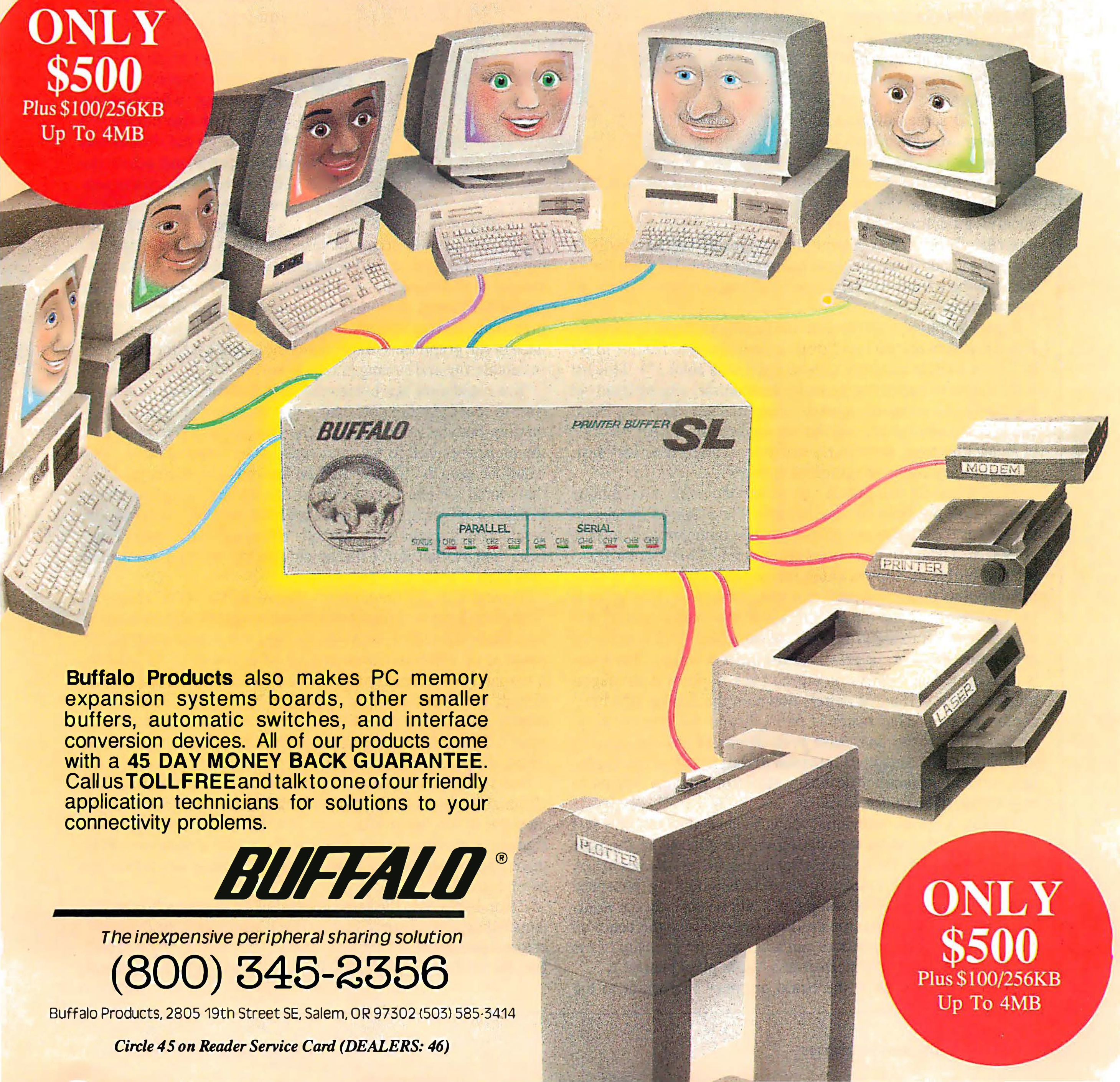
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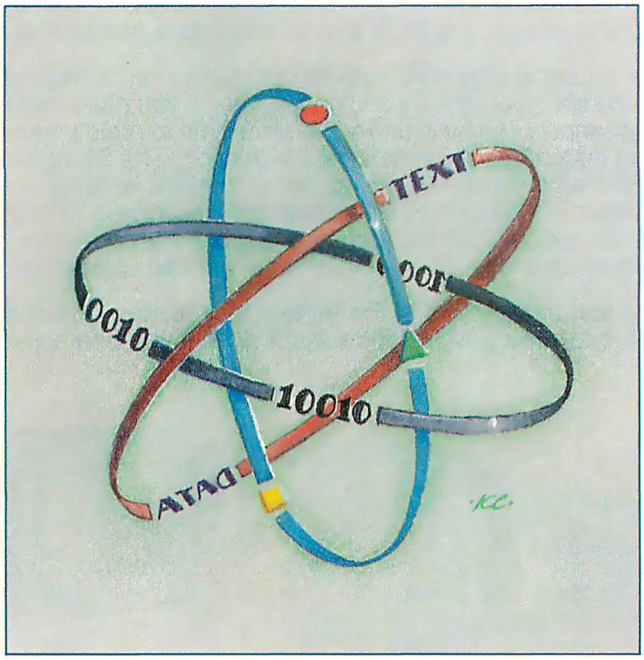
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Display and Video Buffer Fundamentals



This text box provides an overview of two essential elements of the graphics hardware environment. The first is display fundamentals: How do 1s and 0s light up a CRT? The second is video buffering: How does the computer manipulate the data?

Display Fundamentals

Nearly all computer graphics are shown on a CRT video display or monitor. (A few images are sent to primary LCD screen displays, and many are transmitted to peripheral devices such as film recorders or printers, but they follow the same general guidelines that are described here.) The computer hardware and software work in concert to control the electron beam that paints information on the viewing surface of the display—telling it where to aim and when to fire.

Vector graphics systems store the graphics images in memory as a list of vectors (such as "draw a line this wide from A to B" or "draw a circle at center *x,y* and fill it with color *z*"). This list is then used to control the beam in the monitor, aiming it only at the points the computer system wants to show, drawing lines, circles, and other shapes on the screen directly. That's the style of an oscilloscope, some early computers, and a few, very fast, contemporary computer graphics systems.

Most personal computers use *raster scanning,* a technique that controls the beam in another way. The graphics images intended for the display are stored by the computer as a mass of points in a Cartesian coordinate system. This "pointillist" method builds all sophisticated images and all text out of individual points that are on, off, or a particular color. The beam in the CRT starts at the top left corner of the display and strokes across from left to right. It is turned on whenever it is pointing at a picture element, or *pixel,* for the current image. The beam is then turned off while it is moved back to point at the beginning of the next line, or *raster,* down on the display (the horizontal retrace). That raster is painted, and the process is repeated until all the lines have been displayed and the beam is turned off while the aim is returned to the top left of the display (the vertical retrace). The beam then immediately begins to scan across the monitor again.

You don't see the individual scans because they are very fast and because the phosphor coating on the surface of the tube continues to glow for a while after being hit by the beam. (A pixel may actually consist of several neighboring phosphor spots on the screen.) The computer's video subsystem or interface provides the information telling when to turn the beam on and off. (Gray-scale monitors can also vary the intensity of the beam, so that it leaves a more or less bright pixel behind.)

The characteristics of the beam are very important to the computer system. The faster it can turn the beam on and off (the dot-clock or video frequency), the more pixels can be crowded on a line (horizontal resolution). The faster it can move across a line (the horizontal scan frequency) and return to the next line, the more lines (vertical resolution) can be squeezed onto a display image. More lines and pixels mean higher resolution. Some displays also use *interlacing,* which paints every other line during one run through the display and then returns and paints the in-between lines on the second pass.

The equations determining resolution are horizontal scan frequency/vertical scan frequency = lines of vertical resolution, and video frequency/horizontal scan frequency = dots of horizontal resolution. More resolution means smoother diagonal lines and more color or gray-scale mixing options, and this generally aids the appearance of the graphics. It also means more work for the computer in calculating and storing pixels, however.

You could slow the horizontal scan frequency to gain more time to squeeze more dots onto a line for greater horizontal resolution, but you run the risk of the image starting to fade from the phosphors before the next scan cycle comes around. That would be seen as "flickering" on the monitor, the same thing that would happen if you slowed the vertical scan too much. Longer-lived phosphors could fight that problem, but then you would run into the problem of "ghosting" and "smearing" from images that don't disappear quickly enough when their time is up.

Typical U.S. TV frequencies, following the NTSC (National Television System Committee) standard, are 60 Hz for vertical scan (although this is with interlacing; the entire image is updated at an effective frequency of 30 Hz) and 15.75 kHz for horizontal scan. That generates up to 262 lines resolution, although some of these are typically beyond the edge of the display and so aren't visible. Some time is also lost to "overscan," that is running the beam beyond the left and right visible edges of the display.

For a monitor to know when to retrace, it must be given synchronizing signals, with the vertical sync some exact integer multiple of the horizontal sync. TV broadcasts contain these signals; computers must provide them for a monitor. With them, the computer can precisely control when and where the beam is aiming.

Color displays do the same general work as monochrome systems but depend on three beams that illuminate three different-colored phosphors on the tube surface. (A few get by with one gun for all three phosphors.) This RGB (red, green, and blue)

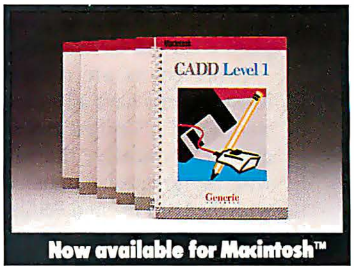
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mechanism requires at least three input signals from the computer, one for each color. A true RGB monitor needs to have these three signals on separate wires. A composite color monitor, much like a TV, can be driven by a single wire that packs all three signals. Because the RGB information is combined and then separated again for a composite system, the resulting picture isn't as clear as on a strictly RGB monitor.

Other colors are made by combining the primary colors. Most systems have a limited number of simultaneous on-screen colors and a limited palette from which those colors can be chosen. Typically, the highest resolution cannot be reached with the greatest number of colors. That's certainly the case with the IBM PC and PS/2s. The Mac, with its fixed resolution, doesn't live by that law. These limits have moved higher as graphics has become more important on personal computers.

Video Buffer Fundamentals

Nothing happens on the monitor that hasn't first been thought out in the computer. For raster-scanned graphics, personal computers use memory-mapped video. That is, they store a logical mock-up of the entire screen's image in a block of RAM called a *video buffer* or *frame buffer.* This series of 1s and 0s can be translated and communicated to the monitor as signals to turn the beam on and off. Application program or operating system operations then change the pattern in RAM, inspecting what is there already and changing it when necessary because of program conditions. The program doesn't even need to know there's a monitor; it just deals with the buffer RAM. The monitor doesn't need to know there's a program; it just accepts information from a video controller that reads the buffer.

Both the CPU running the program and operating system and the video controller have access to that video buffer memory, but not at exactly the same time. Typically, a computer's CPU makes changes to that buffer during the relatively long vertical retrace and lets the video controller have it during the actual raster scans.

There are "video RAM" chips in some advanced computers that have two ports and thus can be manipulated by the CPU and read by the video controller at virtually the same time. A system may also be set up to use multiple buffers if it has enough RAM. In that case, changing the image on the screen can be accomplished simply by telling the video controller to look to another base address in RAM for its next scan's worth of information. The newer buffer's details are sent to the screen while the older buffer is left alone, free to be massaged and modified by the CPU. Later, another instruction can switch back to the original buffer's address. This technique is very important in animation, where large-scale, fast changes are paramount.

A single bit in the video buffer can determine darkness and lightness for a single pixel. Multiple bits can be used in groups to represent the color of a single pixel. This video buffer information can be kept in the same RAM that programs and data are stored in, or kept separately.

The multiple bits of a color pixel cannot be stored physically together and are often gathered into *bit planes*—multiple video buffer blocks of the same size that are logically overlaid. When it comes time to send the information to memory, the bits in the same relative positions of each block team up to specify the gray intensity or color of a pixel. This interleaving is different from system to system and display mode to display mode. It makes more memory control work for the video controller that must feed out the various bits about each pixel at the same time, either to directly drive an RGB monitor or to modulate a composite signal for a monitor. Some computer systems have special hardware registers to streamline this process of bit-plane organization.

Special hardware can also be added to a computer system to accelerate the typical calculations of a graphics program or routine. In this respect, a general-purpose math coprocessor can be a boon to graphics work. But there are special functions that you won't find on typical math coprocessors, functions that are relevant only to graphics. Advanced video controllers may contain graphics coprocessors that can accept macro instructions such as "draw a line" or "place a circle." These coprocessors can offload some of the video buffer manipulation work from the main CPU.

A more specialized graphics function can also be put into silicon. The Bit-Blit operation (bit-block transfer), for example, can move an entire group of pixel values at a time from one buffer position to another (and so move a screen image from one position to another) and logically compare them to the pixels in the new position. Doing that one elemental microprocessor instruction at a time can be very slow. A circuit dedicated to handling the same task can do the job in a fraction of the time and possibly leave the central processor free to do other tasks.

There are also graphics elements, such as *sprites,* that can be implemented in hardware instead of software. A sprite is a group of pixels that moves around on the display as though it represented a single object (these are very popular in game programming). Sprites can be created by software, but if the hardware in a computer has special registers for pointing to the sprite values in RAM and for automatically checking the position of active sprites (which is touching which, and which should be given priority when two or more overlap), the programmer's job is simplified and the program can run more swiftly.

Text-mode raster graphics confines characters to set areas, such as a block of 8 pixels by 8 pixels. A counter or character clock can be used to keep track of which area is being addressed, and a character ROM (containing permanent pixel maps of the characters in a set) or RAM (containing disk-loaded or program-created character maps for the 8- by 8-pixel blocks) is then questioned to see when pixels are lit and when they are dark. Bit-mapped raster graphics, on the other hand, works entirely on an individual pixel basis, without resorting to character blocks. This approach is necessary for sophisticated raster graphics, and it can also handle text. With text, it offers more flexibility in fonts and relative position of characters, but it also makes lots more work for a graphics system and CPU that have to figure out just where and what a character is. Text-mode operations can be several times faster than bit-mapped operations of the same work.

Finally, there is the question of firmware, the graphics software routines that are turned to hardware in ROM, EEPROM, and other special chips. These routines are, in effect, part of the system software, but they are also part of the computer's hardware. Using the routines makes for "well-behaved" programs that avoid disruption of other programs by following the rules. However, using these routines can also slow a program's performance.

Many programs, particularly on the IBM PC—where the interface is not as standardized as on the Mac and Amiga—write information and controls directly to the video buffer and the video controller, bypassing the slow BIOS routines. Such programs aren't as "device-independent" as programs that stick to the regular channels, and they run a risk of breaking under future versions of an operating system.

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In the early versions of the Amiga, the computer was customized for either European use (where the TV standard is PAL) or for use in the U.S. (where the National Television System Committee standard prevails). A new version of the custom chips that should appear this year is supposed to allow any Amiga to produce either PAL or NTSC signals.

Because the Amiga has a TV port, you can directly record any Amiga graphics on a standard VCR. What's more, the custom chips can match their own video synchronization signals to those of an outside source when you plug a so-called "genlock"-compatible peripheral into the Amiga. That means that you can capture single frames from a video stream for modification by Amiga graphics programs and that you can directly overlay standard broadcast or recorded video images with images produced by the Amiga's processors. Neither the Mac nor the PS/2s can go that extra mile without modification and special hardware.

The Amiga display resolutions range from 320 by 200 pixels to 640 by 400 pixels. It can handle 32 colors at a time from a palette of 4096 (or 16 at a time in the highest-resolution modes). A special Hold and Modify (HAM) mode can put all 4096 colors on the screen at once. The Amiga's video buffer is separate from the system RAM and has grown from 512K bytes to a full megabyte of RAM.

The custom chips provide hardware controls for fast manipulation of five bit planes and have special registers and circuits to allow a "dual playfield" (a front image and a rear image that can overlay). Animation subroutines in the system ROM permit smooth movement of objects with a minimum of programmer work. The new Denise chip is expected to add some new display modes, up to 64 colors, and a larger-capacity blitter.

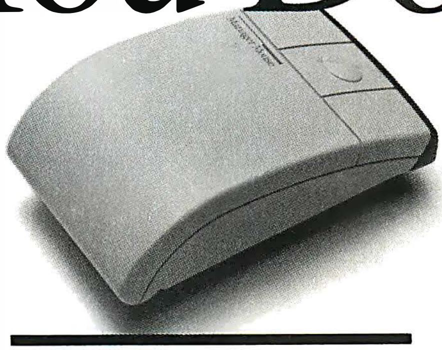
A special video applications graphics mode with resolution of 1280 by 400 pixels interlaced may catch the eye of desktop video enthusiasts. The new chip will "drop in" to the chip sockets of existing Amiga 500 and 2000 models. Commodore is also developing a Professional Video Adapter (PVA) for the Amiga that will be able to generate broadcast-quality titles with smooth color blends and backgrounds.

Although the Amiga can run in a mode similar to the PC's text mode (with the CLI) and can produce WYSIWYG text on-screen, like the Mac's interface provides (with Intuition), its smaller market share has led to a smaller library of programs. The Amiga has also fallen behind the Mac II in the sheer number of colors that can be displayed on the screen—and so is less competitive as a design and industrial or business graphics tool. The Amiga's real strength is shown in pure graphics tasks such as games, animation, and video work. There, it has a clear advantage over the PC or the Mac, with direct connections to standard video formats and with special graphics acceleration hardware to produce smooth and more realistic games and graphics applications. ■

Phillip Robinson, a former engineer and BYTE senior technical editor, is now a BYTE contributing editor who writes about CAD and graphics. He is a founding editor of PIX, *the magazine of digital photography and still video. He can be reached on BIX as "robinson."*

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The RenderMan Interface

Tony Apodaca

Today's state-of-the-art image synthesis will be on your desktop tomorrow

What do the following people have in common: an architect developing plans for a futuristic motel complex, a physicist studying vortex flow in the storms of Jupiter, and a special-effects animator merging his robot characters with live-action footage? The answer: They and many others will soon be generating photorealistic computer graphics images on sophisticated graphics PCs and workstations.

The computer industry has seen a fantastic increase in the speed and complexity of computer graphics hardware systems over the past decade. Many graphics workstations can generate, in real time, wire-frame and simple shaded-surface graphics that would have taken minutes or hours to compute only a few years ago. Personal computers have evolved from toys that displayed text in eight colors to respected machines with high-resolution, full-color graphics.

In parallel, the state of the art in computer graphics research has brought users to the threshold of photorealism in synthetic-image generation. As evidenced by the pictures and films shown at SIGGRAPH and other computer graphics shows, the advent of ray tracing and other sophisticated algorithms, coupled with the powerful computers now available, has made it possible to generate synthetic images that can almost pass for the real thing (see photos 1 and 2).

Unfortunately, these two worlds have remained separate. Fast graphics hardware runs simple algorithms and generates simple-looking images. Photorealistic-image synthesis software runs slowly on large, expensive computers.

It is time for these two worlds to merge. Users will soon demand photorealism on the desktop. Image synthesis will become a standard workstation and personal computer tool, just as desktop publishing has become standard. This new world will need an interface specification that handles high-quality three-dimensional graphics as elegantly as PostScript handles high-quality two-dimensional page layout. RenderMan is such a specification.

What Is RenderMan?

RenderMan is an interface between three-dimensional geometric modeling systems and photorealistic rendering systems (see the text box "The Quest for Photorealism" on page 270). *Geometric modeling* is the process of describing the shapes of objects and the geometric relationships present within a scene. *Rendering* is the process of generating an image

continued

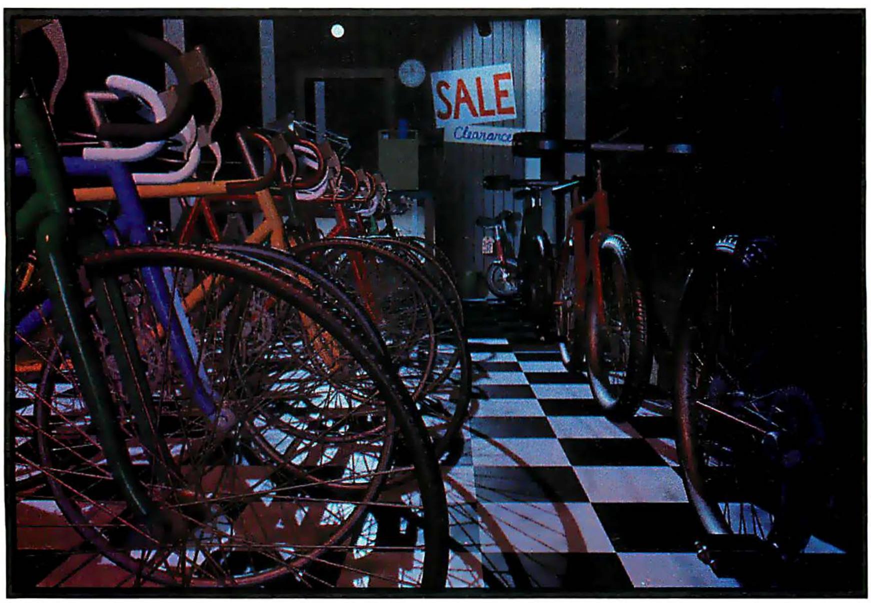


Photo 1: *This computer-generated image of a bike store interior contains thousands of objects, dozens of texture maps, and spotlights with shadows.*

of the scene from a given viewpoint. RenderMan is an interchange standard that permits a variety of geometric modelers to talk to a variety of renderers with a straightforward, common format.

At the same time, RenderMan defines the state of the art in image synthesis. It represents a design goal for the next generation of graphics hardware.

Most current modeling systems and rendering systems are tightly integrated. The companies that supply geometric modelers also supply renderers. The two communicate through a proprietary database or interface.

Users who want to mix and match the best modeler with the best renderer or who want to write their own programs to generate three-dimensional databases and render them are usually out of luck. The interchange standards that do exist (e.g., IGES, Initial Graphics Exchange Specification) address the problems of exchanging geometric databases from one CAD system to another and do not generally provide the additional information that high-end renderers need, such as camera parameters and color and material properties.

Graphics standards have a long history (see the text box "A Brief History of Graphics Standards" on page 272), but the RenderMan specification is different in one major respect. Previous standards generally attempted to capture, in a device-independent library, the capabilities present in the popular graphics hardware of the time. The lengthy standardization process has almost always ensured that by the time a standard is approved and available, the capabilities of graphics hardware will have progressed beyond it.

RenderMan attacks this problem by capturing the state of the art in high-quality image synthesis research and incorporating features and capabilities far beyond those of current graphics hardware. This should help to keep RenderMan viable for many years to come; as hardware improves, an interface will already exist to exploit its power. Modeling companies and users who support the RenderMan interface will have access to new generations of equipment.

The RenderMan interface is a specification for a subroutine library that provides about 100 routines with which a

Users who want to mix and match the best modeler with the best renderer are usually out of luck.

modeler can describe all the information that a renderer might need to generate an image of a scene.

It provides entry points for geometric information, transformation hierarchies, color and material property information, camera parameters, and output image characteristics. The RenderMan interface subroutines are designed in a way that makes the interface easily extensible. In addition, RenderMan provides a programming language (the shading language) you can use to write small programs that describe the material properties of objects in their scenes. This ability to extend the interface and program the shading in a RenderMan renderer gives you tremendously powerful tools in your quest for photorealism.

The RenderMan interface defines only the content and format of the information that modelers pass to renderers. It attempts to be complete, so that any information a renderer might want to get from a modeler can be accommodated.

However, it does not specify how the renderer should be implemented or what the renderer should do with information once it gets it. Thus, you can use RenderMan as an interface to a wide variety of rendering systems with widely varying algorithms, performance characteristics, and hardware assistance—algorithms from hardware polygon pipelines to ray tracers and beyond are all supported. Any features that tailored the standard to a specific style or speed of rendering were removed.

In addition, high-end features whose visible effects are hard to implement were defined but made optional so that simpler renderers that could not handle them could still meet the interface. Thus, as computer speeds increase, rendering software and hardware running on workstations and personal computers will have a clear road map for increasing their sophistication from simple polygon painting to photorealistic image synthesis.

Geometric Information

The RenderMan interface supports a rich variety of geometric primitives, including convex polygons, concave polygons (with and without holes), and polyhedral models, and it has a general interface for specification of the data that is present at the vertices of a polygon. You can specify not only the position, but also surface color, surface normals, and texture map coordinates on a per-vertex basis. In addition, you can extend the vertex structure at run time to include arbitrary information of your choosing, such as temperature, density, or any other values that might be interesting to your particular application.

RenderMan also supports a large number of quadric surfaces, including spheres, cylinders, cones, hyperboloids, paraboloids, disks, and tori. Each quadric primitive can be fully or partially swept in each direction, so you can easily make hemispheres and pie wedges.

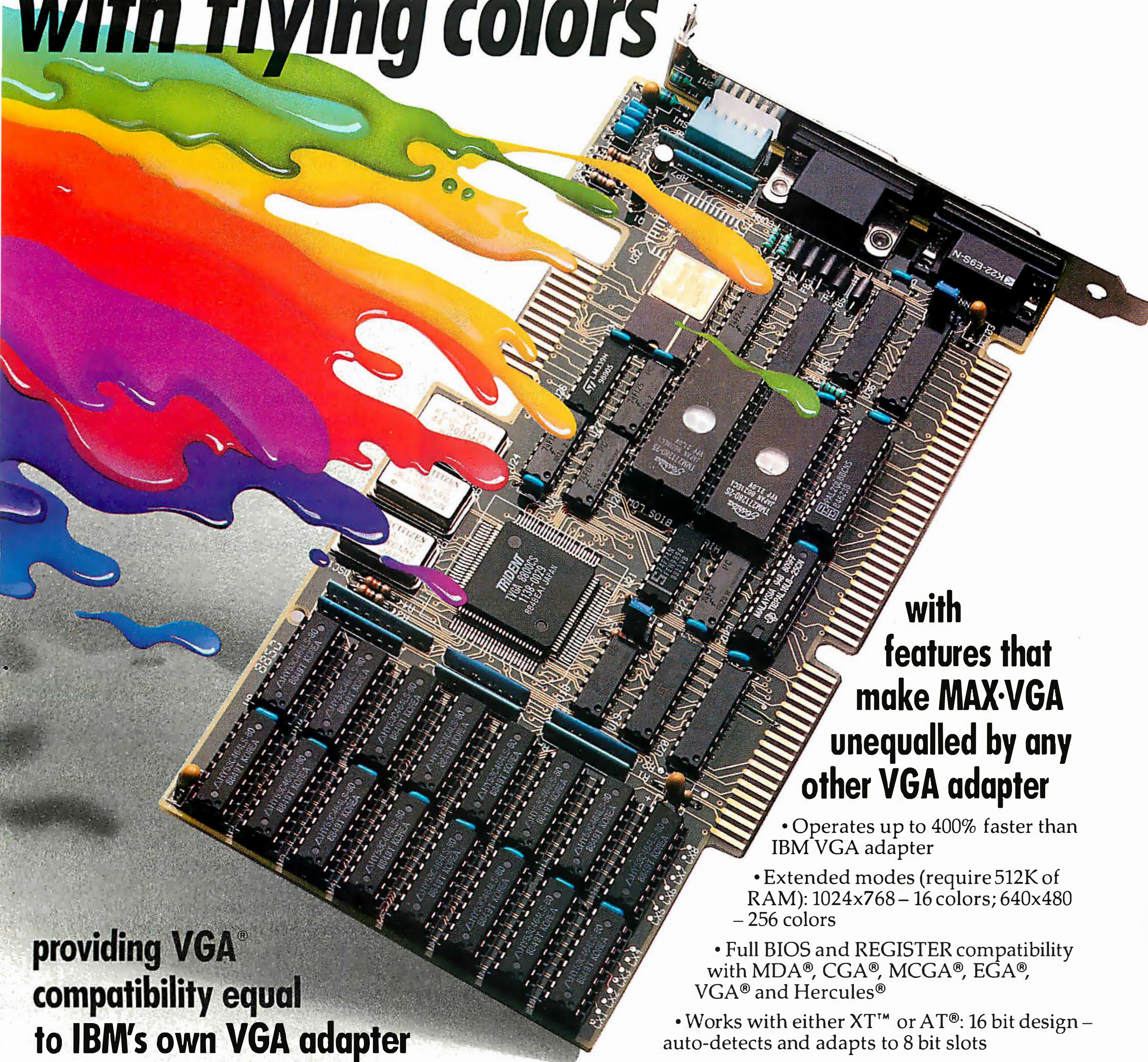
In addition, RenderMan supports a comprehensive bicubic patch primitive. Bicubic patches are curved surfaces that you can think of as the geometric modeling equivalent of rubber sheets. They have many useful properties for model-

continued



Photo 2: *This picture is one of the first computer-generated images to actually pass as a real photograph.*

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The Quest for Photorealism

The first three-dimensional computer graphics systems drew objects as sets of green glowing lines on video display tubes—the familiar *wire-frame drawings* (see photo A). In the 1970s, raster displays progressed to the point where they could be used to draw (or render) objects with sets of colored polygons. The colors were crude, as was the precision of the approximations, but the hidden-surface elimination problem was quickly solved—polygons at the back of an object (usually) didn't show through polygons in the front of the object.

Early systems approximated the effect of a light source on an object by appealing to simple physical laws of diffuse reflection, taking into account how the angle of view and the direction to the light affected the apparent color (the *shade*) of an object at different points on its surface.

In 1971, Henri Gouraud, at the University of Utah, developed an algorithm to smooth out the sharp color changes that happened between adjacent polygons by *interpolating* the colors of the interiors of polygons using the known colors at their corners.

Gouraud's work was followed, in 1975, by that of Bui-Tong Phong. Also working at the University of Utah, Phong developed both a better model for approximating the physics of light and a better way to do interpolation on a polygon, and he gave us the familiar plastic-looking objects that even today are the most common in computer graphics. (It is interesting to note that at this point in 1988 most high-end graphics hardware implements algorithms that are no more complicated than the ones mentioned so far.)



Photo A: *Four light bulbs illustrate the evolution of computer graphics: (clockwise from top left) Gouraud-shaded polygons; wire-frame drawing; Phong-shaded curved primitives with texture; multiple texture and displacement mapping with transparency and shading language.*

About the same time, other researchers (many at the University of Utah) were developing techniques for rendering curved surfaces directly, rather than approximating them with flat polygons. Ed Catmull (then at Utah, now at Pixar) developed a technique for coloring the surface of an object using the pixels of an image to make it look more interesting—*texture mapping*.

In the late 1970s, *antialiasing*—removing the visible stair-steps (jaggies) that occur when images are computed with too little resolution or too few colors—was developed. Jim Blinn, of CalTech's Jet Propulsion Laboratory, improved texture mapping to model bumps on surfaces, and the first attempts at simulating shadows were made.

By 1980, Turner Whitted (now at the University of North Carolina) had improved the shading calculation by adding a more accurate simulation of optics, modeling the way rays of light bounced off reflective surfaces and traveled through refractive surfaces, and thereby gave us the ray tracer. In 1984, researchers at Cornell University solved electromagnetic equilibrium equations as a means of understanding how light bounces off every object in a room.

Meanwhile, Rob Cook (at Pixar) decided that it was impractical for any single shading model to describe the wide variety of subtle lighting effects he wanted and wrote the first shading language to give users more control over how a renderer chooses colors for objects. Many researchers simultaneously attacked the problems of depth of field and motion blur to more accurately model the characteristics of a real camera. Others refined the techniques of using random noise as a source of geometric and texturing complexity to simulate natural phenomena.

The art of photorealistic image synthesis has now reached the point where synthetic images can almost pass as real photographs. The key remaining issues revolve around image complexity (the number and variety of objects in real scenes, and the subtlety of the lighting and shading that happens on them).

ing and rendering. One of these is that you can join several patches to each other smoothly without causing the visible bends or creases that polygons would have (i.e., they can be made to be continuous).

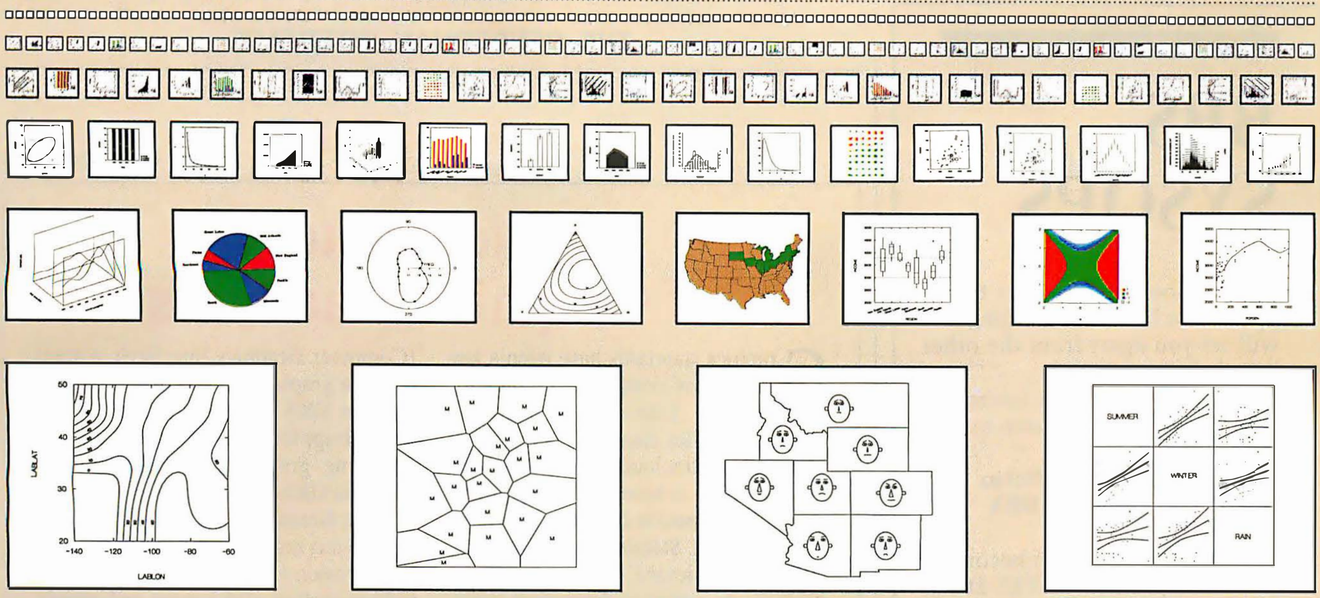
If you work with bicubic patches, you'll be pleased to discover that RenderMan supports bicubics with Bézier, B-spline, Hermite, and Catmull-Rom formulations. In fact, RenderMan lets you specify an arbitrary basis matrix, the mathematical construct that determines precisely how the surface is constructed from the patch data points. RenderMan also supports nonuniform rational B-spline surfaces (NURBS), curved-surface primitives that are all the rage in automotive design circles these days.

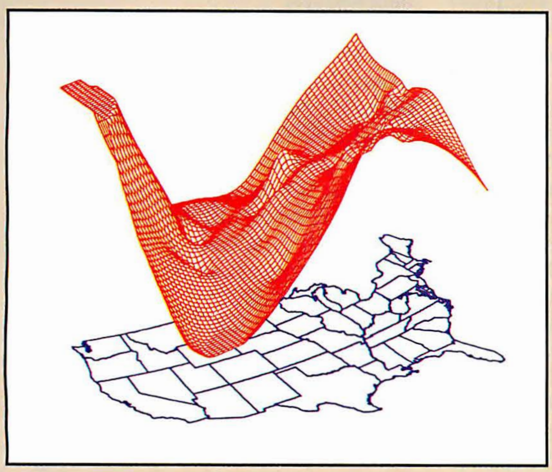
RenderMan is the first graphics interface to support procedural primitives. One of the biggest problems in modeling natural phenomena (e.g., mountains, plants, fire, and so on) is that the geometric complexity is enormous.

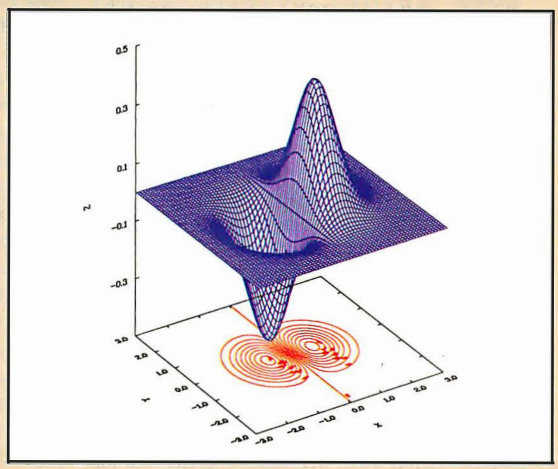
This problem is usually solved by writing programs that generate all the tiny detail rather than modeling it by hand. However, it can still be very expensive for the modeler to generate a huge complex model and pass it to the renderer, particularly if the modeler doesn't know how much of it the renderer really needs.

RenderMan's procedural primitives

continued







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A Brief History of Graphics Standards

Graphics standards have been a key element of computer graphics for over a decade. Like all standardization efforts, graphics standards come about because vendors and users realize that their industry is hampered by a profusion of incompatible hardware and software systems. Standards promote portability and device independence for applications software, important qualities in the fast-changing computer industry.

The earliest proposals for graphics standards, Core (1977) and GKS (Graphical Kernel System, 1978), were developed to solve the need for two-dimensional output. They dealt with primitives such as lines, markers, and polygons filled with crosshatch patterns or color. They also had reasonably extensive text capabilities and handled interactive input from several devices.

More recently, the need to produce three-dimensional drawings has been addressed by a standard called PHIGS (Programmer's Hierarchical Graphics System, 1984). This standard addressed three-dimensional lines, markers, polygons, and text, and added the notion of a hierarchical model, which allowed users to manipulate the graphical database (e.g., rotate it in three dimensions, modify the colors, and so on) without having to respecify the entire database from scratch.

Associated with each of these graphics standards has been a series of related proposals to extend their functionality to new situations. GKS spawned CGI (Computer Graphics Interface), a standard for graphics devices that would implement GKS efficiently; CGM (Computer Graphics Metafile), a standard for archiving graphical descriptions in a file; and GKS-3D, an extension of GKS to three dimensions that rivaled PHIGS. PHIGS has recently spawned PHIGS+, an extension to include hidden-line and hidden-surface elimination and simple light sources.

Each standard has been developed through the deliberations of a number of standards bodies such as ACM SIGGRAPH, ANSI, and the International Standards Organization. The trip through the standards pipeline is long—GKS was finally approved as an international standard in 1984, and a C language binding (a formal list of the official C subroutine calls) was finally approved last year.

Graphics standards can also result from industry acceptance of a clean and powerful interface proposed by a single company or group of cooperating companies. De facto standards such as PLOT-10 (a two-dimensional plotting package), X (a window management package), and PostScript (Adobe's page-layout language) have emerged in this way. De facto standards are developed and refined more quickly than official standards, particularly since there is a guarantee that a conforming implementation is available; however, the fact that they are not official sometimes limits their acceptance among competing companies.

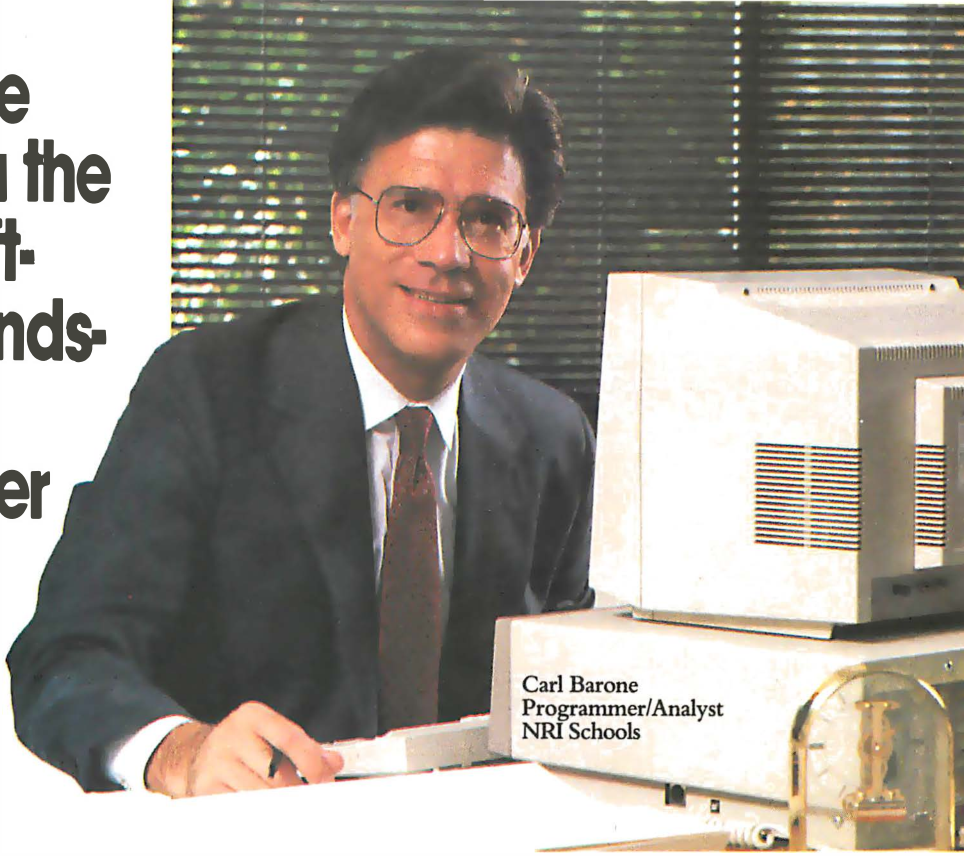
permit you to give the renderer a pointer to a subroutine that will expand simple objects into more complicated ones, such as converting a triangle into a fractal mountain or a sphere into a particle system explosion. Using procedural primitives, the modeler can download a very complex model, such as a fractal, to the renderer in a carefully controlled way that sends only the required amount of detail through the interface.

No three-dimensional rendering interface would be complete without hierarchical modeling, and of course RenderMan supports it. There is a full set of transformation operations (e.g., rotate, translate, scale, and skew), which can be pushed onto, and popped from, a hierarchical transformation stack. This permits modelers to easily define articulated models (e.g., a robot), where the position of one piece depends upon the position of another piece further along. Constructive solid geometry, a technique for defining objects in terms of the sums and differences of solids (e.g., a solid block with a cylindrical hole cut out of it), is also fully supported.

Shading Information

RenderMan has a large set of routines for defining shading information. You can set both the color and the opacity of objects, and you can specify colors not

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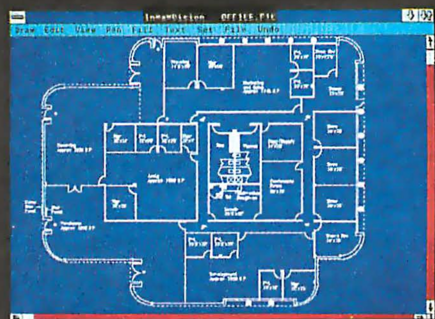


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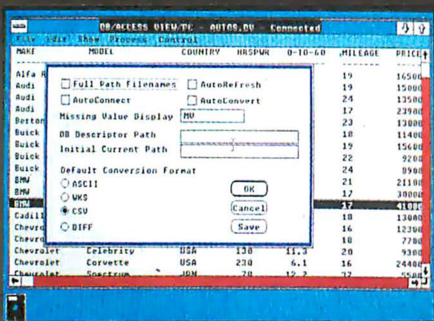
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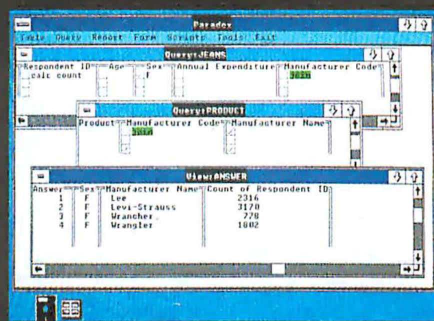
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merely in the RGB coordinates typically used in computer graphics, but also in multichannel spectral colors if the need arises. The use of spectral color permits renderers to more carefully compute the ways in which some objects reflect and refract light at different wavelengths (e.g., a prism).

One of the most important features of the RenderMan interface is its strong support for user-definable material characteristics. You can define up to four separate shading language programs that provide different material characteristic information about each object: a *surface shader*, which determines what color you see when light reflects off the surface; a *displacement shader*, which can move the surface by small amounts to add dents or fillets that are too small or too complex to model geometrically; a *light shader*, which describes how luminous objects emit light; and a *volume shader*, which describes how light is attenuated as it passes through the interior of a translucent object.

While this may seem complicated, it's actually a straightforward way to think about the material properties of objects, particularly once you've seen these shaders in action.

Special Effects

You specify the camera position and orientation using the same hierarchical transformations that describe the positions of all the other objects in the scene. RenderMan lets you specify other parameters of the simulated camera, as well, in order to provide information to renderers that support advanced rendering features.

For example, you can set the shutter time as well as the focal length, focal distance, and f-stop of the camera to simulate motion blur and depth of field. Photography buffs will recognize motion blur as the effect that occurs when a fast object moves across the camera's field of view during the interval that the shutter is open (see photo 2).

RenderMan lets you specify the positions, shapes, and colors of the objects at multiple times during the shutter interval. This is so that sophisticated renderers that can simulate motion blur will know how the objects are moving.

High-quality rendering requires a lot of attention to the sampling and filtering that are performed on the output pixels in order to avoid *aliasing*—the "jaggies." RenderMan offers independent control over the number of shading samples per pixel and the number of hidden-surface samples per pixel, as well as the size and shape of the pixel filter function.

Besides the standard display parameters of output image name, device type, and resolution, RenderMan supports gamma correction and exposure control. These functions compensate for the tendency of a monitor's phosphors to glow with exponentially increasing brightness as voltage increases linearly. RenderMan also contains the new concept of an *image shader*, another shading language program that lets you implement various color manipulations on final pixels just before they are put into the frame buffer or file.

Shading Language

I've mentioned the RenderMan shading language several times. Now I want to take a close look at it. Most renderers have a subroutine that determines the color of the surface of an object. Typically, this subroutine implements a single

continued

mathematical equation that uses a simple model of the reflection of light to calculate the contributions of the light sources and texture maps to the surface color.

The equation often has many parameters (5 to 20, depending on the renderer) that you tweak to control the appearance of different kinds of materials (e.g., plastic, metal, and chalk). Very often, however, you want the surface to have some characteristic you can't achieve with the fixed equation, and you want to use a texture map to modify some parameter that the implementers didn't think you would want to modify. What can you do?

If you are fortunate enough to have the source code, you can add your function and recompile. If not, you are out of luck. RenderMan changes this situation. It provides the shading language, a C-like programming language that has new functions and data types designed to calculate colors based on geometric information. Programs that you write in the shading language are typically small (10 to 20 lines) and are loaded into the renderer at run time when they are requested by some part of the scene geometry.

These programs then replace the built-in shading equations. You can use this language to customize shading on a per-object basis. This new freedom gives you the power to model the appearance of objects as carefully as you model their shapes.

The shading language supports three basic data types, the `float`, the `point`, and the `color`. `Point` and `color` are abstract data types that are actually vectors of length three (`color` can have more than three components when spectral color is enabled). The standard C arithmetic operators (*, +, /, etc.) work on these data types. In addition, there are some new operators for vector dot and cross product.

The familiar C conditional and looping constructs are available (except `switch`), as are subroutine definitions and calls. There is a rich library of mathematical functions, as well as a library of functions that implement common shading operations such as normalizing vectors, transforming points between coordinate systems, calculating diffuse and specular lighting, interpolating colors, splining, and calculating pseudorandom numbers.

The renderer calls the appropriate shading language program (the shader) every time it requires a light intensity, surface color, and so on. When a shader is called, it has access to a large number of global variables that the renderer provides. These variables include all the geometric information that the renderer knows about the surface being shaded, such as the position `P`; the surface normal `N`; the color `Cs` and opacity `Os` that you specified; the texture coordinates `s,t`; and others. The variables that you applied to the vertices of your primitives are also available inside the shaders.

Each type of shader accomplishes its specified task by calculating and modifying a specific part of this global state. For example, a surface shader is responsible for calculating and setting `Ci`, the color that the eye sees. A light shader is responsible for setting `Cl`, the light color.

Listing 1 is an example of a basic surface shader. Using a simple equation, this shader calculates the reflectivity of a metallic object. It uses the standard library functions `ambient`, `diffuse`, and `specular` to determine the amount of light arriving on the surface from the light sources.

Listing 1: *A simple shader that simulates the reflection of light off metallic objects.*

```
surface metallic (float Ka=.4, Kd=.4, Ks=.6,
          roughness=.25;){
     N=faceforward(normalize(N));
     Ci=Cs * (Ka*ambient() + Kd*diffuse(N)
          + Ks*specular(N, -normalize(I), roughness) );
}
```

Listing 2: *A shader that simulates wire mesh by varying the opacity of the object.*

```
surface wire_mesh (float Ka=.4, Kd=.4, Ks=.6,
                 roughness=.25, nu=2.0, nv=2.0;)
{
  if (mod(u*nu, 1.0) > 0.5 && mod(v*nv, 1.0) > 0.5){
    Oi=0.0;                       /* Transparent! */
      } else {
    Oi=1.0;                       /* Opaque metal! */
    N=faceforward(normalize(N));
    Ci=Cs * (Ka*ambient() + Kd*diffuse(N)
          + Ks*specular(N, -normalize(I), roughness));
    }
}
```

Listing 3: *A shader that simulates dents by moving the surface a small amount. This adds visual complexity that is very difficult to model convincingly using standard geometric modeling techniques.*

```
displacement dent (float scale=1.0;)
{
    float size=1.0, displace=0.0;
      for (i=0; i<6; i+=1.0) {
      /* Calculate a simple fractal 1/f noise function */
      displace += abs(.5 - noise(P * size)) / size;
    size *= 2.0;
    }
    /* Displace the surface and recalculate surface normals */
    P += N * pow(displace,3.0) * scale;
    N = calculatenormals(P);
}
```

These functions implement three customary equations based on the direction and strength of the incoming light. If those functions are not appropriate, the surface shader has access to the lights and can calculate whatever values it pleases from them.

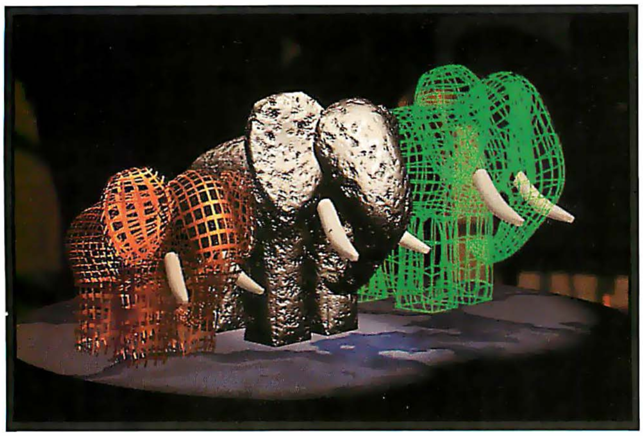
The shader then calculates a weighted average of the incoming light intensities and multiplies by the color of the object. Notice also that the shading language automatically takes care of the multiplication of float values by color vectors, freeing you from having to write the ugly loops that would be necessary in most other languages.

The type of shader (in this example, `surface`) indicates its intended function. Parameters to the shader are specified using a syntax similar to that of ANSI C. This shader demonstrates another unique feature of the shading language, the presence of default values in the parameter list. When a modeler requests this shader, it specifies by name the parameters it wants to override. Any parameter not mentioned is left with the default value.

You can examine a slightly more complicated shading language function in listing 2. Every geometric primitive has a two-dimensional surface, and renderers typically define a simple coordinate system (known as *parametric coordinates*) on this surface in order to apply texture maps and do similar functions that need to vary along the surface. This shading language function uses a bit of tricky arithmetic on the parametric coor-

continued

Photo 3: *The lead toy demonstrates the metallic and dent shaders, the golden toy demonstrates the wire-mesh shader, and the large toy uses a similar shader reminiscent of wire-frame drawings.*



dinates u and v to decide whether to make the surface opaque or transparent at each point. This has the visual appearance of cutting a hole in the object.

Listing 3 illustrates a displacement shader. A displacement shader moves the position of the surface around a little bit to simulate tiny fillets, dents, and other minor surface perturbations. This adds to the visual interest of an object and makes it look more realistic. This particular shader calculates a fractal dentedness using several iterations of *noise*, a function that produces a semirandom value that changes slowly over the surface of the object (using a purely random value would distort the surface beyond recognition, since adjacent points would have no relationship to each other).

Photo 3 shows the effect of using these shaders on a simple model of a toy. Achieving the same effect by trying to model the individual metal bands or the intricate surface dents would be extremely difficult.

You can see the value of complex shading using texture maps and nontrivial shading-language shaders by comparing photos 4 and 5. Photo 4 is a model of the inside of an office, generated using the AutoCAD modeling system and a simple renderer.

Photo 5 is exactly the same geometry file, but the objects were given custom material characteristics using the shading language: There are shadows; several objects have texture maps; there are reflections in the waxed floor and bookshelf; there are subtle displacements implementing fillets on the chair and books. Each of these shaders is a few lines long, and the difference in image quality is astounding.

Photo 4: *An office floor-plan model with simple shading. (Data courtesy of AutoDesk, Inc.)*

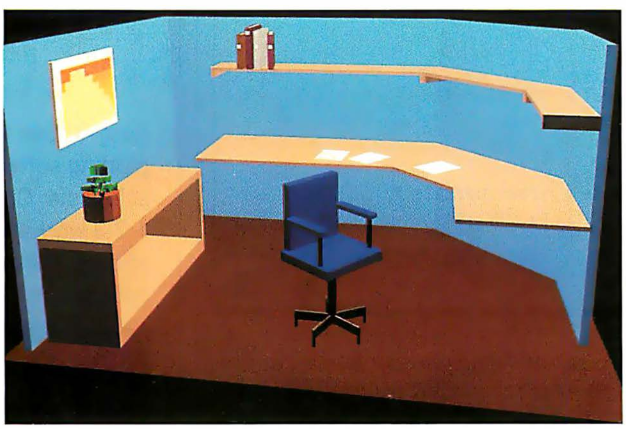
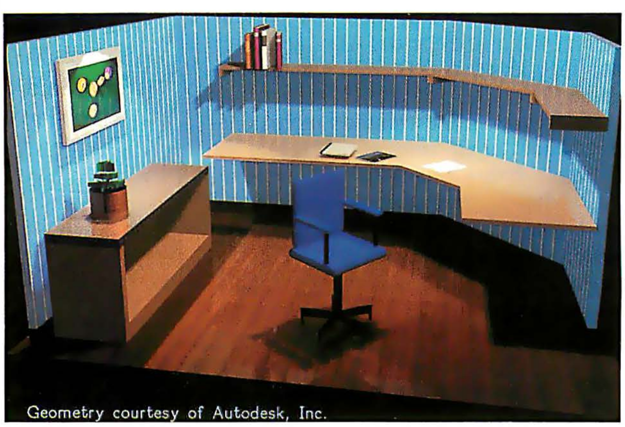


Photo 5: *The same office floor-plan model with custom shaders, textures, and shadows.*



Wrapping It Up

RenderMan is a powerful interface between three-dimensional modeling systems and photorealistic rendering systems. It represents the first graphics interface to deal with issues in high-quality synthetic-image generation such as antialiasing, texture mapping, motion blur, shadows, spectral color models, and programmable shading languages.

These advanced features are not available on most of the rendering software and hardware currently available. Thus, RenderMan represents a goal for sophisticated new graphics hardware and rendering software to shoot for.

Users of graphics workstations and personal computers will be the biggest winners, as photorealism becomes inexpensive, commonplace, and compatible across a wide range of platforms.

Pixar publicly announced the RenderMan interface last May after over six months of industry review by computer graphics workstation manufacturers, software vendors, and sophisticated end users. At that time, 19 companies endorsed the specification as a common interface to high-quality computer graphics.

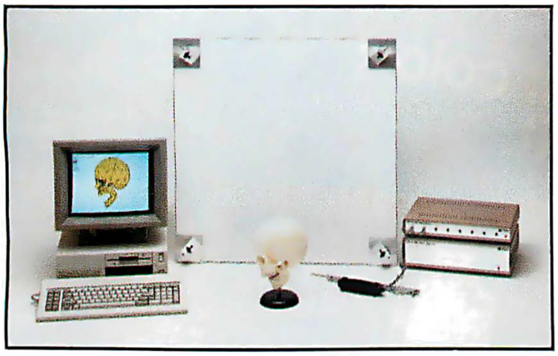
Many of these companies are working on products that adhere to the specification, and these products will probably be announced in the next six to 12 months. Once these products appear, it will only be a matter of time before everyone has photorealism on the desktop. ■

Editor's note: *Copies of the RenderMan Interface version 3.0 are available from Pixar, Inc., 3240 Kerner Blvd., San Rafael, CA, 94901. Please enclose $15 to cover the cost of printing and mailing.*

Tony Apodaca, a software engineer at Pixar, Inc. (San Rafael, CA), has a master's degree in computer and systems engineering from RPI. He can be contacted on BIX c/o "editors."

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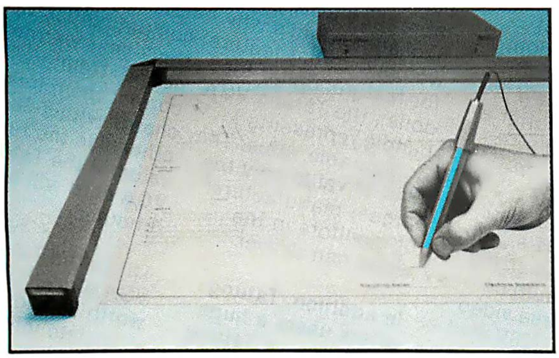
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Interacting with the Tiny and the Immense

Craig Mundie

Scientific visualization lets researchers see the unseeable

An important part of scientists' work is to think of ways to represent information so that they and others can understand what's going on. Visual images help scientists develop and share their insights and theories with colleagues, by providing an effective way to pass along the mental images that are the basis of their thoughts. Computer graphics can facilitate the transfer of research results from one scientist to another by generating precise graphical representations to illustrate important points. When the relatively new capability of animation is applied to graphical representations, more insight into the data can be attained.

In this article, I'll describe some of the philosophy and techniques behind scientific visualization and discuss where it's heading. I have included photos that demonstrate the results of scientists' work in several areas.

The Importance of Visualization

Scientists and engineers have long understood the importance of pictures in perceiving and communicating the functional relationships in quantitative data. Graphical devices, such as contour plots, structural diagrams, or ball-and-stick models, have long been familiar tools in sciences such as physics, chemistry, and cartography. And since the early 1960s, scientists have used computers to perform calculations and manipulate the resulting data for output in graphical form on plotters and display terminals. Computers greatly expanded the volume of data that could be handled, and graphical displays eased the chore of understanding data by presenting relationships visually.

The human being's ability to comprehend pictures stems from the fact that over half the brain's neurons are used to process and understand visual input and that the brain's ability to take in this information is enhanced by a visual input data channel with a bandwidth estimated to be about 2 gigabits per second.

Higher-resolution graphics display terminals now let scientists view data in three dimensions rather than two, extending their capability to understand the data. Three-dimensional color representation provides a global picture of the data—one displayed image can represent 10 million numbers. This gives scientists the ability to see simultaneously all the information that otherwise might have to be printed on reams of paper. This substantially cuts the amount of time required to discover whether or not the data represents a sensible result.

But maximum individual productivity will not be attained until researchers and scientists are able to control not only the display of the images generated but also the computation of data that is used to generate the pictures. The goal of scientific visualization is to give researchers the ability not only to view pictorial representations of the data as they are generated but to promote insight into the meaning of the data by allowing researchers to modify the computational process as it is occurring.

Extending the Capabilities

Scientific visualization extends the capabilities of computer graphics technology by giving researchers better control of the process by providing added levels of functionality. Scientific visualization, the conversion of massive amounts of data into pictures that show the results of computations, moves beyond ordinary simulation techniques. It can be an animated, interactive process in which scientists can manipulate data and, in real time, see the results of their changes. Under the umbrella of scientific visualization, the previously discrete disciplines of computer graphics, image processing, computer vision, CAD, signal processing, and user interface technology are applied to scientific research.

While the term scientific visualization simply refers to the use of images to interpret scientific data, its most important function is to provide researchers with the means to *interact* with the graphics in such a way that real-time interpretation of data is possible. True interactive visualization offers scienctists impressive advantages that include better analysis, improved productivity, and cost savings.

Full-function scientific visualization is now available primarily to groups of researchers who work at supercomputer installations. (See the text box "PCs and Scientific Visualization" on page 280 for a look at the personal computer's future in visualization.) To make the technology more widely available throughout the scientific community, the National Science Foundation is urging implementation of a federally funded initiative in the area. An NSF Panel on Graphics Image Processing and Workstations report released in late 1987 on "Visualization in Scientific Computing" encourages the formation of interdisciplinary teams with a mix of skills to produce visualization tools that can be shared among diverse research areas.

The NSF panel and its recommended initiative are the results of many factors. Spurring the effort is increased recognition that the volume of scientific data being produced is overwhelming the ability of researchers to comprehend it. Coupled with this backlog of uninterpreted data is the recent introduction of advanced graphics technologies that promise to better handle vast amounts of visual data as well as the recognition that even more

continued

PCs and Scientific Visualization

The evolution of computing sheds light on the role that personal computers will take in scientific research in the future. These advances portend a day when an intimate partnership will exist between desktop computers and high-capacity machines. This partnership will extend the benefits of scientific visualization to more and more researchers by allowing personal computers to serve as viewports into the data generated by supercomputers. The large and growing numbers of personal computers within organizations have given individuals necessary computing resources, but the organizations themselves often no longer can access the peak computational capacity that they require.

This situation is analogous to equipping 100 astronomers charged with studying a distant star with 100 pairs of binoculars instead of providing them with a single large-aperture telescope. Just as even the most powerful binoculars cannot gather much useful data on the star, the most powerful desktop computer is fundamentally the wrong instrument for some applications.

The Right Resource at the Right Time

To escape this dilemma, all computer users must be provided access to whatever level of resource they need on a demand basis, with the personal computer serving as the access point. The ability to bring this model to reality hinges on the evolution of a human-to-machine interface that is adequate to support transparent escalation of computing capability. Until it arrives, users are stuck with either big computers that have poor human interfaces or user-friendly personal computers that lack the capacity to solve really big problems.

A harbinger of what is to come for personal computers with future technology is today's multimedia workstation, which has the ability to interface to more extensive sources of data and information than can be generated locally or outside the scope of traditional alphanumeric or simple graphics displays. The impact of multimedia workstations is now seen particularly in training areas where it is possible to interact with the pictures accessed from compact disks or VCRs and displayed on the screens of personal computers. It is also seen in the image management systems that are able to store, manipulate, and interact with image data.

To make visualization more accessible, the capability of both the server computer that generates the pictures and the desktop client computer that displays them must be extended. Also, today's networking technology must evolve to complementary networks that are better suited to dealing with images and pictures.

The ability to interact with pictures across heterogeneous machines is necessary not only in the network, but more importantly in the hierarchy of the computing environment. It will extend into the server and potentially into other special-purpose machines, be they larger supercomputers or special-purpose architectures that provide other particular services in the environment.

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massive amounts of data will be generated as new supercomputers emerge.

The problems of examining or assimilating the vast and growing quantities of numerical data result from increasing use of computer-based data acquisition techniques in fields like medicine. Medical diagnostic imaging, for example, generates massive amounts of data. Until recently this data was captured and used in photographic form, but it is becoming increasingly common to acquire it in digital form and to process it for review on visual display terminals.

Supercomputers are producing vast amounts of data for researchers in natural sciences like geology and astronomy and in physical sciences like chemistry and physics. As each new generation of supercomputer provides the capacity to handle larger and larger problems at far greater speeds, and as powerful "minisupercomputers" act as computing resources to increasing numbers of researchers, more and more experimental data will be produced in each of the scientific disciplines. And orbiting satellites continue to send streams of data from space to earth, vastly increasing the amount of geophysical and astrophysical data available to researchers and analysts. But facilities for its examination and use are being tasked to the limit by the vast data sets.

As the volumes of available data expand, researchers are increasingly hampered in fully understanding it. For example, much of the data being acquired from satellites orbiting earth is merely stored on tapes and sent to government warehouses because facilities for interpreting and understanding the data are simply not available. To prevent further waste of acquired data, it has become essential that researchers and scientists find more efficient ways to process it.

Today's Visual Applications

Ideally, scientists want to be able to compute phenomena over a time span, create a series of images that illustrate the interrelationships of various parameters at specific time periods, and analyze these images at a workstation. Although this ideal has been achieved only at certain select locations, many scientists and researchers have put visualization techniques to use in their work.

Of all applications, molecular modeling makes the best and fullest use of the interactive three-dimensional technology available today. For years, research scientists have been drawing diagrams and building molecular models to gain insight into the way that molecules' structure influences their properties. But Styrofoam and wire only vaguely represented the real thing. The space that molecules occupy is not solid but consists of clouds of electrons moving at the speed of light. And molecules are not static; as the energy level of a molecule varies with time, its geometry changes.

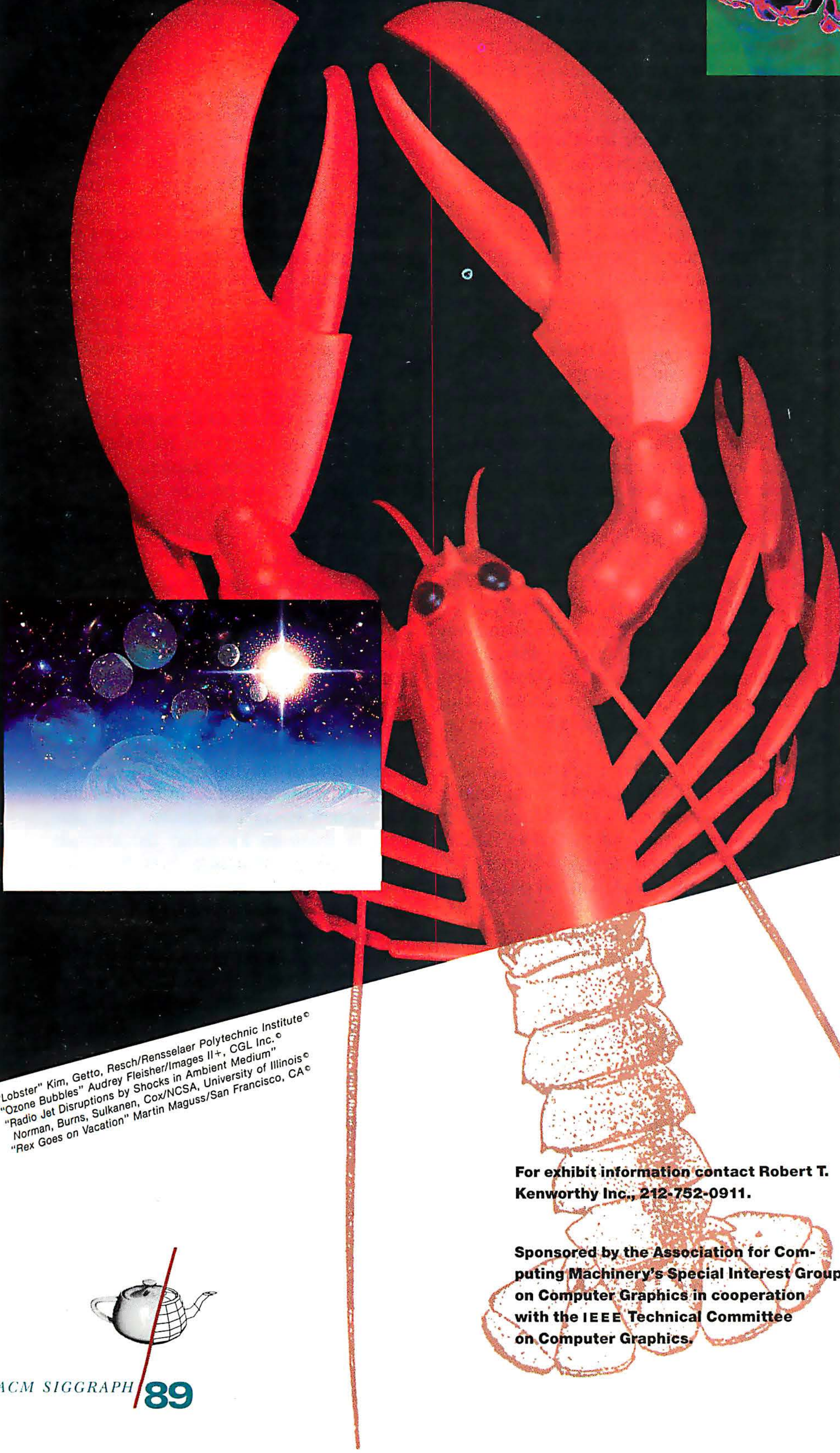
Scientific visualization techniques have enabled researchers to analyze the forces generated by electron clouds and view animations of dynamic molecular sequences. The knowledge gained has been used to develop laundry soaps and shampoos; lighter, stronger materials for aircraft; and effective pharmaceuticals.

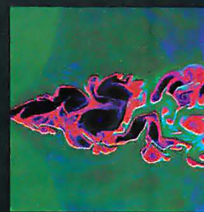
When used in designing drugs to combat specific diseases, visualization makes the process more rational than previous experimental methods. It allows researchers to analyze a compound's electronic charges and the three-dimensional shape of its molecular structure before the drug is fabricated in the laboratory to determine if it will be effective against a disease. Researchers can display the disease on a host molecule and pinpoint the active site, where the disease-causing agent attaches to healthy molecules. Having determined the shape

continued

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and energy charge of the active site, they then display prospective drugs in the active site and can actually measure the fit and energy charge of each combination. Only drugs that actively combat the disease are then compounded in the laboratory and clinically tried.

Materials research deals with polymers that are made up of molecules consisting of thousands of repetitions of one relatively simple structure. The characteristics of the molecules determine the properties of the material. Modeling polymers using computer graphics enables researchers to investigate proposed new materials without the expense and time of synthesizing them in the lab.

Enzymes are the active ingredients in laundry soap and shampoo. To rid garments of the stains caused when proteins bind to fabric molecules, detergents provide an alternative bonding compound. This bonding compound is more attractive to the protein than fabric, causing the protein to release the fabric, bind to the detergent molecule, and be rinsed away. The structure of the molecule and the way that molecules fit together in the protein chain determine how they interact with other molecules. By displaying representations of the enzymes and the molecules to be modified, researchers can see how they interact and decide which parts to modify to produce the desired result.

Photos 1 through 5 illustrate some of the capabilities of scientific visualization in several research areas. All photos in this article were rendered on an Alliant FX/80 at the University of Illinois National Center for Supercomputing Applications.

Planning future defense systems; battle management systems; and command, control, and communications systems for the military are areas of research that involve complex theoretical simulations. Visualization techniques allow researchers to prove theoretical concepts before committing to the expense and time of building a prototype that may or may not work. For example, to be effective, spy satellites must be able to cover their intended area of surveillance. By simulating in real time the area of the globe that will be covered by an orbiting satellite, it is possible to detect flaws in the plan. An algorithm may show on paper that the satellite provides the desired coverage, but real-time simulation may detect flaws by running various scenarios that cover an extended period of time. One such simulation revealed that a surveillance satellite that was intended to cover the globe's surface, in fact, at a particular period of the year, failed to cover the U.S. at all!

Because tomorrow's weapons systems and military vehicles will be run by computers, it is important to determine whether the personnel charged with controlling them will be able to react fast enough. Simulations performed with a human in the loop reacting to the stream of data provided by the computer have proved that humans can react fast enough to respond as required.

Using visualization techniques in stress analysis allows the detection of potential flaws within materials that could never be seen by a human performing a visual inspection. By performing calculations on an aircraft's fuselage, for example, and displaying potential stresses, potential failure spots can be predicted for current aircraft structures. The procedure involves knowing the stresses throughout the structure, how the material performs at certain temperatures and the kind of environment in which it operates, simulating steady and dynamic stresses, and arriving at a conclusion about how long the craft can remain in service. These same techniques also can be applied to buildings, engines, or any other structures.

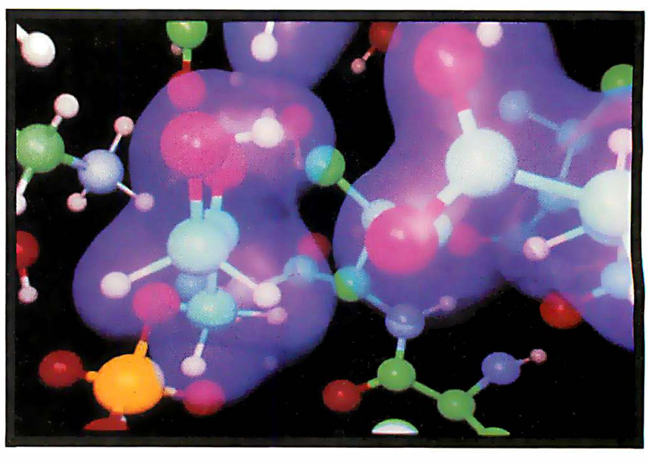


Photo 1: *Enzyme reaction in trisphosphate isomerase. (Research by Paul Bash of Harvard University; visualization by Stefan Fangmeier.)*

Gluing the Techniques Together

What is evolving now is the glue to tie all these technologies and techniques together in a way that makes them available to individual researchers and scientists. Traditionally, large-scale simulations have been performed using long runs in batch mode on a time-shared supercomputer, and the usual pathway from supercomputer to graphics display or plotter peripheral was through a mainframe or minicomputer.

Because the very large solution data set resides on the supercomputer where it was generated and much of the work needed to render a visual image from the data set is highly compute-intensive, in some cases the supercomputer is also required to perform a large part of the graphical processing necessary to produce an image. But time on a supercomputer is expensive, and much of the graphical processing necessary is a highly repetitive, time-consuming process. Therefore, some installations are taking data generated by the supercomputer and using dedicated peripheral processing equipment (e.g., geometry engines, graphics accelerators, and image computers) to generate the images in a more cost-effective manner. These dedicated graphics processors are integrated with or attached to workstations to allow researchers to interact with the images.

Supercomputers can be connected via LANs to high-performance workstations with integrated graphics capability. This approach, however, because of the workstation's limited computing power and data storage capacity, and the relatively low data transfer speed provided by the network, requires that the supercomputer perform at least some of the postprocessing necessary to reduce the volume of data sent to the workstation. And researchers are still denied the ability to interact with the process in real time, as the LAN can act as a bottleneck to high-bandwidth communication, hampering the workstation's ability to generate displays in a rapid sequence.

Visual supercomputers contain all the hardware elements required for scientific visualization in one box. They tightly integrate high-performance graphical subsystems into the computer's memory, eliminating the LAN bottleneck. These systems provide simultaneous computations and graphics, allowing researchers to view the results of their work while they make changes in computations.

Special image-passing networks currently under development will allow image data to pass between server (the

continued

supercomputer or minisupercomputer) and client (PC or workstation) systems at very fast rates. This technology will make the use of scientific visualization possible for most scientific and engineering users by eliminating the speed bottlenecks that are encountered when trying to transmit large amounts of pixel data.

Another approach uses powerful graphics workstations. Designed to provide both the computational capability for simulation and the visualization capabilities, in stand-alone mode, machines such as these are useful in problems that don't rely on the massive data set that makes supercomputer capability essential or to provide postprocessing for graphics display. These are typically single-user workstations that allow the user to do either computations or graphics, but not both at the same time.

Whatever the means used to achieve it, the trend toward more interactive supercomputer use is growing. High-speed paths can be provided between supercomputer and workstation to permit a researcher to get into the computational

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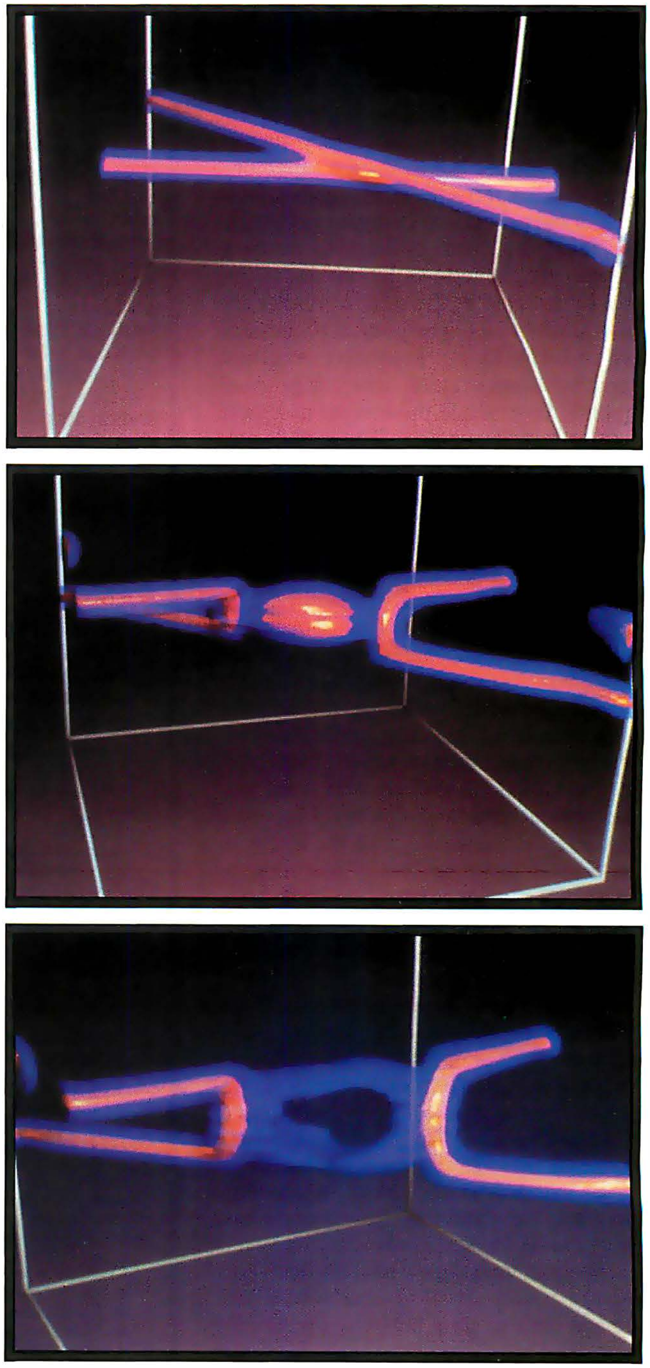
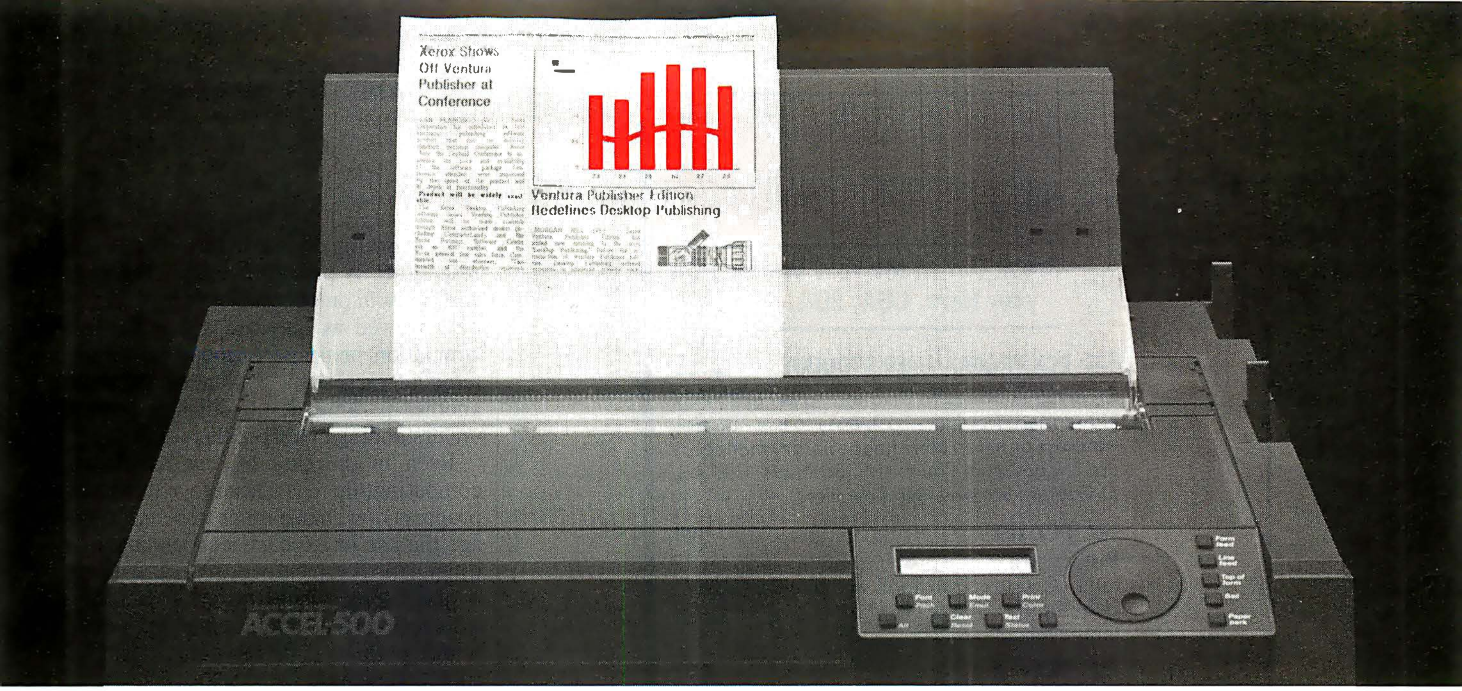


Photo 2: *Cosmic string interaction. These three renderings show a cosmic string collision at a crossing angle of 135 degrees and at a velocity of 75 percent of the speed of light. (Research by Richard Matzner, Department of Physics, University of Texas at Austin; visualization by Stefan Fangmeier.)*



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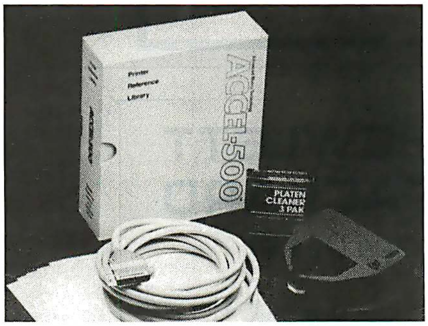
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loop. Working on-line to the computer, a researcher is provided with high-bandwidth visual output that enables results to be reviewed as they are obtained. The simulation being performed can be altered interactively to explore the effect of another parameter, providing a greater understanding of the problem.

Even in the case of long-run batch computing, there is a need to monitor the progress of a run in order to better manage the use of expensive supercomputer time. This is typically done by providing a quick-look visualization capability. This approach also requires a high-bandwidth path to transfer data from the supercomputer to the graphics display.

Another challenge is to provide the kind of graphics software that will give potential users access to the features of visualization hardware. This software must be able to utilize the most powerful features of the hardware, it must be flexible enough to accommodate changes in hardware technology, and it must provide human-to-machine interfaces that are friendly and attractive to users in a variety of scientific disciplines.

Much of the visualization software currently in use was developed for particular hardware configurations or to support research in a specific scientific discipline. Some visualization centers use adaptations of commercially available systems that were created to perform image synthesis and animation applications, to attain visualization capability.

Computer graphics and digital image processing have traditionally been two distinct technological activities aimed toward different types of applications. Many scientific disciplines benefit most when techniques and technologies from both graphics and imaging are merged. Visualization techniques combine the two activities. Visual comparison of theory with observation is an example of this utility. Experimental or observational results are frequently depicted by images that are captured by photography or other sensing technology. Theoretical results, on the other hand, are represented as imagined physical models. These models are interpreted as geometric objects that can be rendered into images using computer graphics techniques. Comparison of the images produced by the two techniques requires the application of image-processing technologies.

Completing the Picture

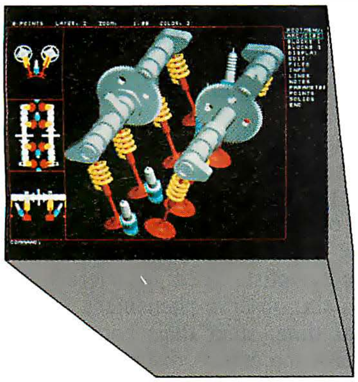
Cultural differences between scientific and artistic users of visualization tools, as well as technical differences between

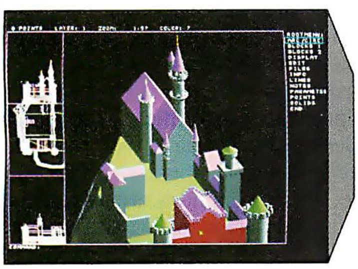
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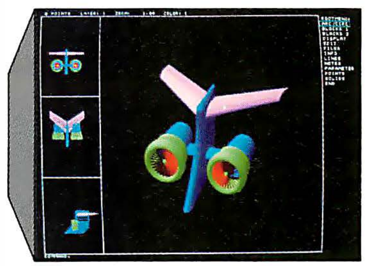
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end-user scientists and computer scientist computing center managers must be overcome to provide the scientific community with access to visualization technology. The teams being formed to implement visualization technology, such as the University of Illinois National Center for Supercomputing Applications group, are designed to accomplish this by bringing together scientists and graphics experts. A common understanding of the diverse problems faced on either side will provide the knowledge and sensitivity needed to overcome difficulties and will result in tools that can be effectively used by researchers in many disciplines.

Ideally, scientists want to be able to compute data, generate sequences of images, and analyze these images at a workstation. However, workstations that are capable of providing high-performance, high-resolution graphics often are priced outside the researchers' budgets. But many scientific problems can be analyzed interactively without high-quality three-dimensional graphics. Scientists don't always require dazzling presentations to benefit from visualization techniques. They need very high-quality visualization to present or publish known information, lesser quality to share information with colleagues, and a third type of visualization to study phenomena by themselves or with collaborators.

While presentation images require the use of powerful equipment and the assistance of visualization experts, when graphics are used to share scientific discoveries among peers, the primary requirement is for clear visual representation of information. This can be provided by equipment as simple and inexpensive as a video recorder in a graphics workstation.

Personal graphics for scientific analysis is the most important of the three types of visualization because it results in the greatest productivity. This is where scientists need to interact with their data, observe phenomena in close to real time, steer their computations, and have the effects displayed immediately on the screen in graphical format. The emphasis is on data representation and interactivity, not on quality. It is at this level that next-generation personal computers will take a more active part in the scientific process.

Already providing high-resolution color graphics capabilities, next-generation personal computers will also offer higher levels of computational performance, better communications capabilities to speed data transfer, and a better-designed human interface to encourage widespread use by researchers. The price levels at which these tools will be made available will enable even the most cost-conscious project director to put them on every researcher's desktop. ■



Photo 3: *Tornadic storm. This is the moment at which a storm becomes a tornado. (Research by Bob Wilhemson, research scientist at NASA; visualization by Stefan Fangmeier.)*

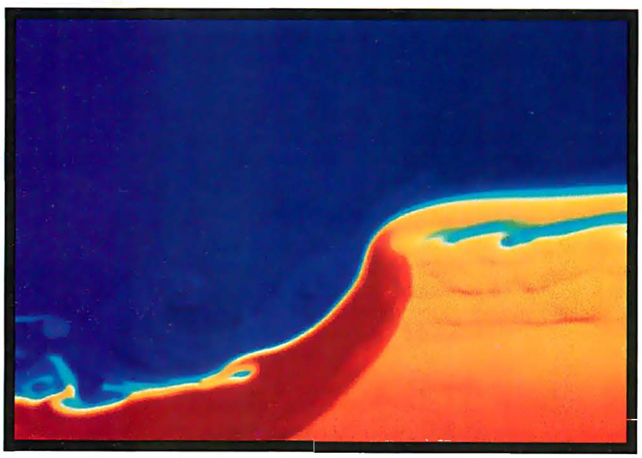


Photo 4: *Formation of Venus plasma clouds and streamers. (Solar wind research by Robert Wolf and Michael Norman, astronomers at the University of Illinois; visualization by Stefan Fangmeier and Matthew Arrot.)*

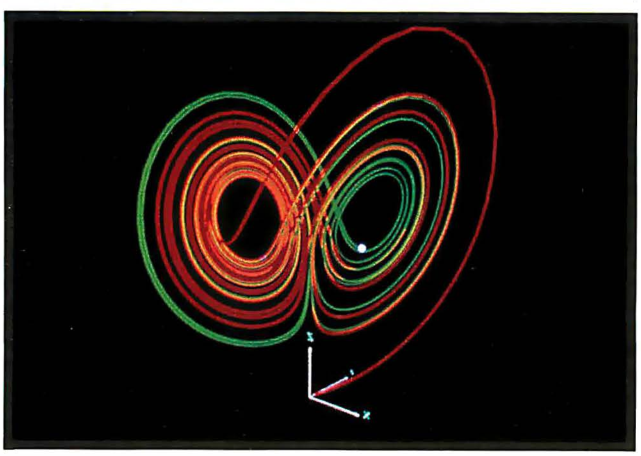


Photo 5: *A visualization of the first system of equations in which the "chaos" phenomenon was discovered. (Research: David Hobill, Dan Simkins, and Michael Welge, University of Illinois; visualization: Jeffery Yost.)*

ACKNOWLEDGMENTS

I would like to thank the following people for their contributions to this article: chemistry applications, Dr. Paul Weiner, chemist, Alliant Computer Systems Corp.; techniques, history, and future developments, Stefan Fangmeier, chief scientific visualizer, University of Illinois National Center for Supercomputing Applications; structural analysis, Neville Rieger, president, Stress Technology, Inc., Rochester, New York; simulation applications, Scott Adcock, manager of computer graphics, Colsa Corp., Huntsville, Alabama.

Craig Mundie is vice president of R&D for Alliant Computer Systems Corp., Littleton, Massachusetts, a maker of supercomputer visualization systems. He can be reached on BIX c/o "editors."

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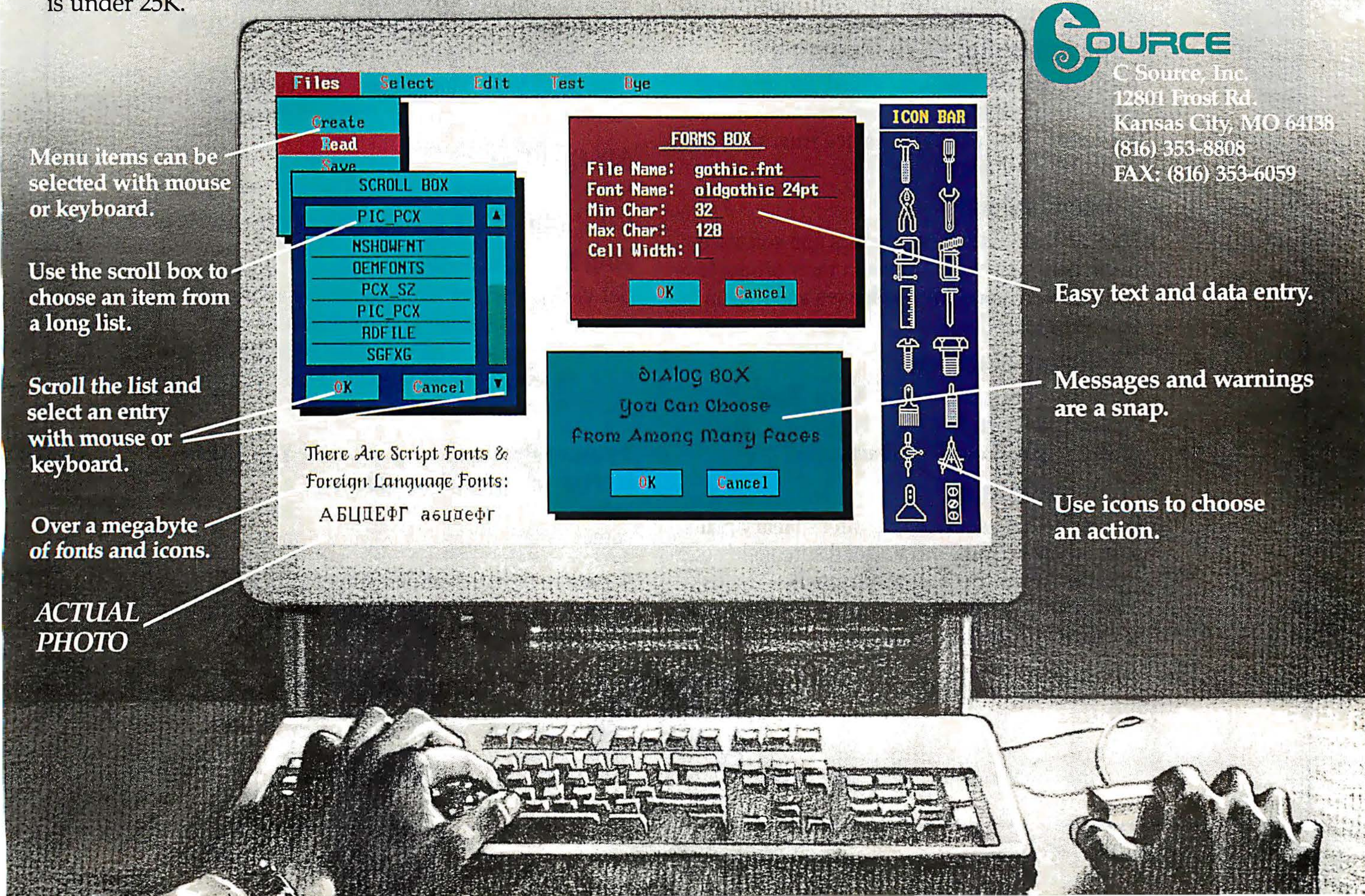
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TUESDAY, 4/25, 9 PM EST. How to avoid TSR traps and more.
Terminate and Stay Resident programs remain full of traps for the unwary programmer, but Barry Nance can rescue you. The BIX Technology Group Moderator will share with you his experiences with TSRs—and his sample code in Turbo-C and assembler. (join cbix)

THURSDAY, 4/27, 8 PM EST. And you thought you've had telephone trouble?
Find out what it's like trying to telecommute from really remote sites. Join BIX Telecomm Group Moderator Brock Meeks as he recounts his adventures last month in Afghanistan, where he was a correspondent for a San Francisco newspaper (toting his faithful Model 200 and Toshiba 1000). (join cbix)

All-Month Conferences

BYTE's *In-Depth* section this month is on CASE. BIX will augment it with a month-long examination of CASE, featuring Ron Schroeder, Associate Professor of Applied Computer Science, at the Southern College of Technology, in Marietta, Georgia. The discussions will be in our software-engineering conference. (join soft.eng.)

BIX's Contact conference will examine the blurring distinctions between science-fact and science-fiction in the age of superconductors, biologically engineered life forms and humans living in space for extended periods. Whether you're in the "fact" or "fiction" camp, you'll want to share information and debate the issues, in preparation for the 6th annual CONTACT symposium in Phoenix, April 27–30. (join contact)

Geoff Gilpin, author of the JANUS/Ada Extended Tutorial, will conduct an online Ada tutorial this month. (join janus.ada)

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The TRON Project

An open architecture, a family of VLSI chips, and system software designed to revolutionize the way we use computers

Ken Sakamura and Richard Sprague

Computers are now used in every product imaginable, from household appliances to automobiles to calculators, yet there are no standards for letting those computers communicate with each other. A standardization effort called TRON (The Real-Time Operating System Nucleus) aims to establish a set of common data-interchange standards that will make it easy for all computers to communicate in real time.

The central philosophy of the TRON project is that computers will become more distributed and their uses more varied, and that the overall power of computers will increase if they can work together. There are few standards for communications between PCs and mainframes and among multiple character sets.

Another issue that has been largely ignored involves standards for real-time, as well as multiprocessing, communications between devices. The user feels these problems, too: Incompatible interfaces between systems make it difficult to imagine different computers as part of a single world network.

TRON is an ambitious, broad-based response to these issues and has already received the participation of many of the major Japanese computer companies and leading semiconductor makers, as well as a number of U.S. and European software and hardware companies. The name TRON applies to the development of the whole concept, not a specific product. TRON encompasses the development of an open architecture, a family of VLSI chips, and system software.

TRON's designers consider an open-architecture philosophy essential and believe it is the most important factor in its receiving wide adoption by manufacturers. For this reason, all TRON specifications are available for adoption by anyone, free of charge. TRON standardization is coordinated by a nonprofit organization, the TRON Association, in cooperation with the University of Tokyo.

The three most important aspects of the TRON project are the concept of highly functional distributed systems, operating system software on the TRON PC, and the TRON CPU.

Highly Functional Distributed Systems

Until the popularization of LANs and other means for easy exchange of data among desktop computers, PCs were largely kept independent of one another. A primitive means of PC-to-PC communication existed—writing data to a floppy disk, and hand-carrying that disk to another computer. But in general, documents developed on one machine were not typically used by other machines.

Exactly the same situation now exists for computers used in embedded systems, such as the microprocessors that are now standard components of everything from microwave ovens to VCRs. Primitive means of data-sharing sometimes exist, but only on a case-by-case basis using specialized products. For example, some advanced calculators offer add-on interfaces that let you exchange ASCII data with the IBM PC, and crude devices exist for communication with VCRs. But there is nothing comparable to the easy connectivity among desktop computers now available with LANs.

TRON's essential goal is to bring the concept of networking to all computers, including those used internally in consumer products. IBM's Systems Application Architecture (SAA) has a similar purpose, but its scope is limited to traditional computer systems. The TRON operating system, however, defines multiple application-specific architectures covering every domain in which computers are used. These areas are

- ITRON, for embedded industrial systems;
- BTRON, for business-oriented workstations;
- CTRON (central TRON), for large file servers in networking environments;
- MTRON (macro TRON), for interconnecting "intelligent objects" and super personal computers or workstations.

Each of the TRON subfamilies is designed to be compatible with the others (see figure 1). A good analogy of how these families work together is the open system interconnection, or

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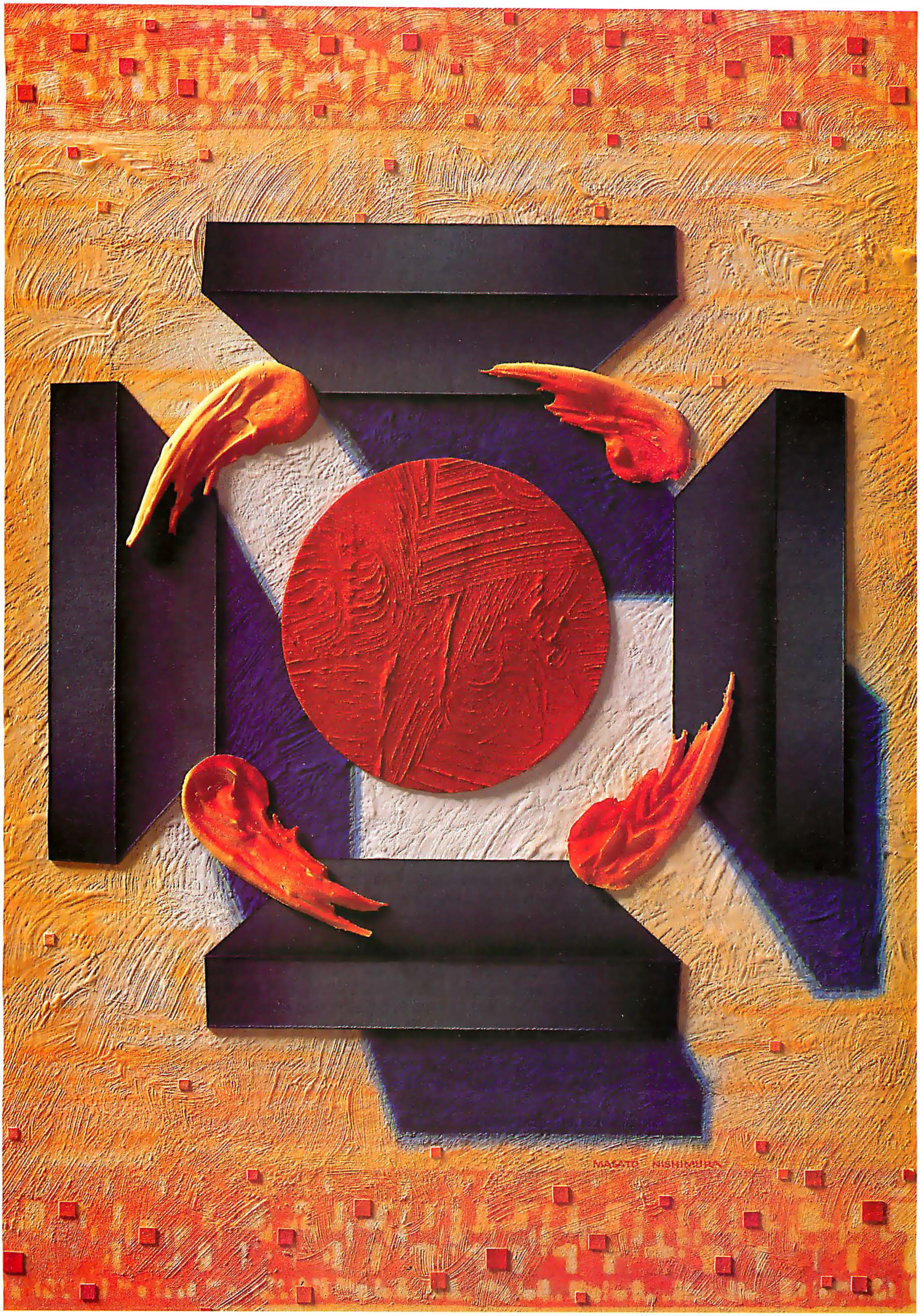


ILLUSTRATION: MASATO NISHIMURA © 1989

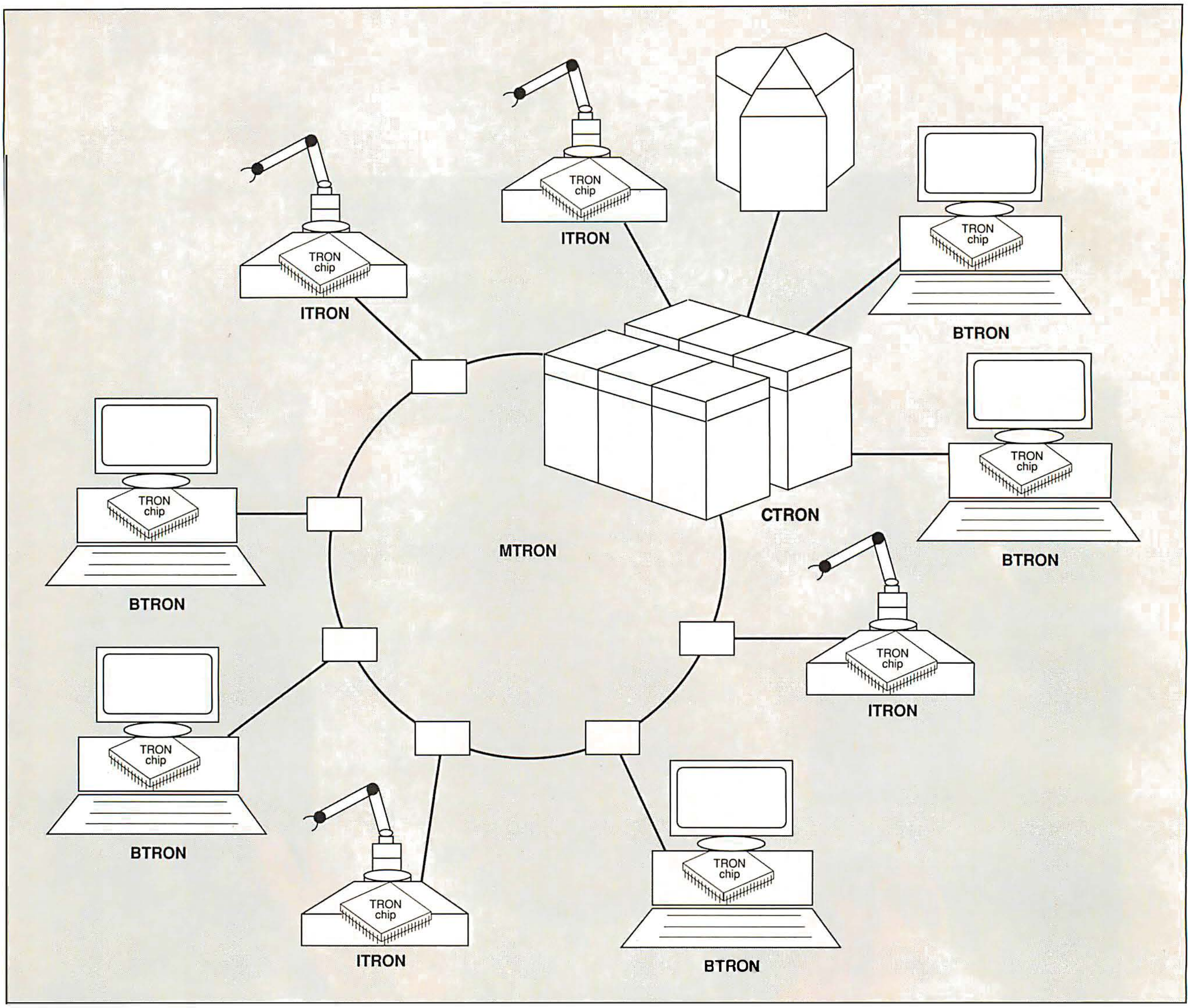


Figure 1: *In the TRON world, BTRON workstations can communicate with ITRON industrial computers and share data with a mainframe through a CTRON file server. The network linking these and other "intelligent objects" together is MTRON.*

OSI model, well-known in the data communications industry.

Like the OSI model, the TRON project is divided into layers: an instruction-set-processor layer, an operating-system kernel layer (which is separated into the I/B/C/MTRON architectures), the operating-system shell layer, and an application and human/machine interface layer. Also like the OSI model, work on the individual TRON layers can proceed independently of work on the others, with confidence that the resulting total TRON architecture will fit together.

The four separate operating-system kernels are designed to satisfy the broad categories of applications that will need interconnection by computers of the future. The four are used independently, but they are designed to easily exchange data.

The ITRON and CTRON Kernels

In the industrial field, microprocessors use many real-time operating systems. None of these operating systems has distinguished itself as a standard in the way Unix has become a de facto standard in the field of software development. ITRON is an attempt to create such a real-time standard.

Industrial applications require fast response time to external signals, and the ITRON specification has been designed to permit it. Using a two-level approach to standardization, ITRON tries to achieve rapid response time with a very low overhead.

On the upper level, the TRON project defines a machine-independent logical interface, which includes universal aspects of real-time systems such as intertask communication. The second level is a CPU- or architecture-dependent part, which determines the performance of real-time systems.

The ITRON specification includes a wide variety of system calls, many of which can be removed from the kernel to improve the performance of a specific application. For example, although ITRON specifies task synchronization primitives for semaphores, event flags, mailboxes, and others, an application that uses only semaphores may legally remove all the other synchronization primitives from the kernel.

CTRON is the specification for a multiuser operating system that works with machines and networks linked with ITRON and BTRON. It is designed for applications that require very large data bases and memory storage or extremely fast process-

ing. CTRON is also oriented toward high-speed, high-quality printing, graphics, and voice processing.

The MTRON Kernel

In the future, microprocessors will be found in an ever greater variety of products. Walls of TRON houses will have processors that sense temperature and pressure variations and send the information to microprocessor-controlled doors and windows.

Massive numbers of processors, called *intelligent objects,* will require real-time control by, and compatibility with, other TRON computers. The smart network that links them together is called MTRON. An underlying programmable specification language called the TRON Universal Language System (TULS) makes it possible to design a set of standard communication protocols to coordinate all these intelligent objects.

The ultimate goal of the TRON project is to build a highly functional distributed system in which billions of intelligent objects can be connected to work cooperatively.

The BTRON Kernel

The TRON family that will ultimately be most important to the PC and workstation industry is BTRON, an open-architecture specification of computers meant for use as personal workstations by businesses and homes. People will want future business- and home-oriented computers to be easy to use, so the BTRON design pays careful attention to its user interface.

Users of window-based systems, like the Macintosh and Microsoft Windows, will be familiar with many of BTRON's user-interface design techniques. Another BTRON feature that will be especially appealing to the international market is the ability to deal with large character sets. BTRON imposes no constraints on the size of its character set.

Since BTRON machines require much more interaction with users than other TRON families, the user-interface specification is the most critical part of the design. BTRON relies heavily on bit-mapped graphics, and input can be done with either an ergonomically designed keyboard or a pointing device, a stylus that the TRON project designers consider superior to the mouse for most tasks (see photo 1).

New applications for computers based on the BTRON concept were created for users of individual computers networked with other computers and used as mediums for information exchange and presentation. BTRON defines several functions to make this condition possible.

The BTRON specification supports the processing of large numbers of different characters in as many languages as possible (if possible, all the characters used in the world). Unlike the 8-bit character-based operating systems of the past designed to handle the Roman alphabet only, the BTRON specification begins with a more generalized approach to language processing.

The BTRON specification allows both 1-byte and 2-byte codes to coexist. A 1-byte code permits the use of 2^8 (or 256) characters; a 2-byte code permits the use of 2^{16} (or 65,536) characters. This feature permits the storage efficiency of 8-bit codes for Roman-like languages, while enabling the elegant representation of large character sets for languages like Japanese. The operating system allows each language to choose its

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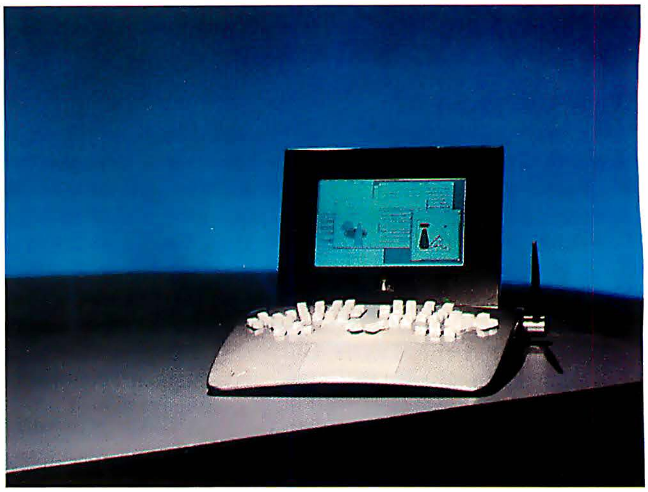


Photo 1: *The BTRON standard PC includes a flat-panel display, an ergonomic keyboard, and a stylus pointing device. Everything from the CPU instruction set to the user interface was designed as a unit.*

own algorithms for direction of writing, formatting rules, and input methods.

BTRON provides a common format for the representation of graphical data. The operating system includes hypertext-like features such as an outline processor and the ability to link documents in network fashion.

The BTRON Real-Object/Virtual-Object Model

A file system is the part of an operating system that provides for the storage, representation, and management of data. Most file systems consist of static ASCII data stored in files, which are grouped into directories. In Unix and MS-DOS, for example, directories are themselves files that can be created, deleted, and moved. BTRON's file system uses a very different model called the real-object/virtual-object model. This system is a set of specifications designed to efficiently handle data in the BTRON operating system.

BTRON stores a collection of data in a *real object* referenced by multiple tags called *virtual objects*. A real object, like a conventional document, can contain text and figures in any combination. Real objects can also contain virtual objects (i.e., pointers to other real objects), a feature that provides a hypertext-like ability to structure data into its semantic components.

Virtual objects ordinarily appear as rectangles on a bit-mapped display (see figure 2a). These rectangles can be manipulated by selecting them with a pointing device. When a virtual object is opened (see figure 2b), it displays the contents of the real object it points to (in this case, a bit-mapped graphical figure of a clock).

In the real-object/virtual-object model, a real object is made up of ordered variable-length records of data, called segments. There are four standard types: text, figures, virtual objects, and *fusen* (a Japanese word pronounced "foo-sen" meaning "a stick-on label").

Text and figures are primitive segments for information transfer, and BTRON requires that the main text of an object be readable. This fact, plus the ability to nest virtual objects inside real objects, provides a simple hypertext-like feature as a basic component of the operating system.

There are two different types of real objects, with the difference lying in how the segments are stored within the real ob-

ject. In one type, called the one-dimensional real object (or "text" real object), segments are stored sequentially (see figure 3a). In the other type, called the two-dimensional real object (or "figure" real object), segments are arranged in a two-dimensional overlapped manner (see figure 3b).

Figure 4 summarizes the basic features of the real-object/virtual object model:

- Real-object data can be displayed in one or two dimensions.
- Viewports onto the real-object data can be nested.
- Real-object relationships are handled by a linked network of pointers.
- Objects are linked together by either virtual objects or opened virtual objects.

As with the Macintosh operating system, you can start a BTRON application by specifying a real object to be processed and letting the system determine the pertinent application. In this sense, the BTRON environment resembles the object-oriented systems that are being used on PCs and workstations.

In reality, however, the BTRON data model more closely resembles the conventional method of separating data and program because it also allows the opposite relationship: Different applications can be used for the same real object. This relationship is possible because a real object knows which applications can be invoked on itself. The knowledge is stored in the *function fusen* segment, which contains the parameters required for linkage to the application program.

With the basic editor, users can modify fusen and gain a variety of benefits, including the ability to specify default parameters and automatically invoke programs.

Efficient and free data compatibility between all computers is an important part of the TRON project. BTRON uses a model called the TAD (TRON application data bus) concept to provide for this data exchange. The purpose of the BTRON TAD protocol is to define the record structure corresponding to each segment in a real object. TRON applications should conform to the TAD protocol as much as possible. Therefore, a real object created by spreadsheet programs can be read by word processors as numeric text data, or a real object created by graphical chart programs can be read by a graphics editor.

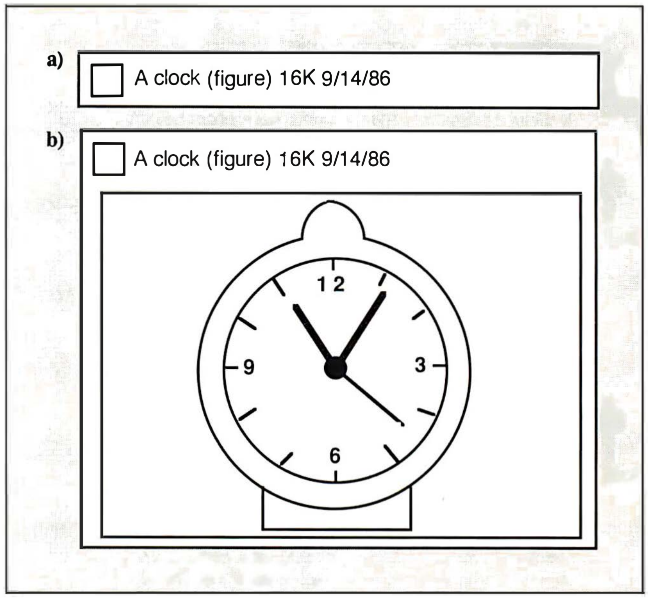


Figure 2: *A BTRON virtual object is normally displayed as a rectangle* (**a**), *which, when opened* (**b**), *displays the contents of the real object it points to.*

In conventional computers, general data compatibility is typically guaranteed only on the level of ASCII text. Spreadsheet data from Lotus 1-2-3, for example, can be loaded into most word processors or communications programs only after being stripped down into raw text, losing its essential numeric content. Graphical charts generated from that data become meaningless when converted into text this way.

Under BTRON, however, all data is divided into two parts: one that can be shared and one that is application-specific; the

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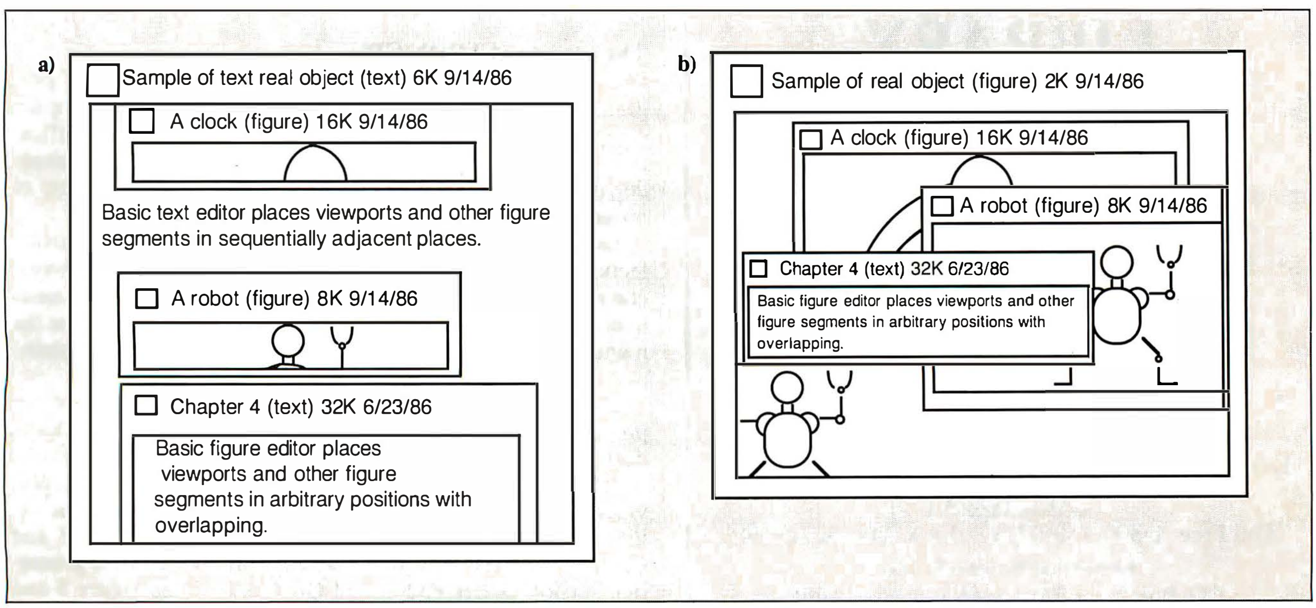


Figure 3: *In BTRON, one-dimensional real objects (or text real objects) are stored sequentially* (**a**), *while two-dimensional real objects (or figure real objects) are arranged in a two-dimensional overlapped manner* (**b**).

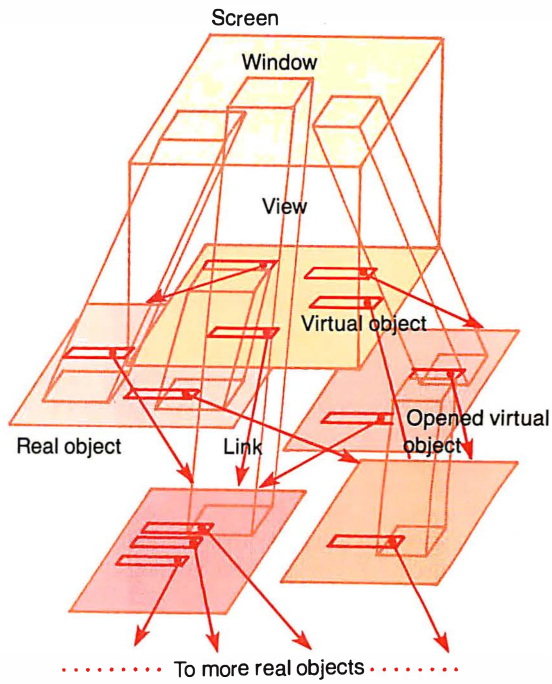


Figure 4: *All BTRON data is stored in a real-object/virtual-object hierarchical structure. Real objects can be arbitrarily linked, and the virtual objects they contain can be nested to any depth.*

shared data is standardized with TAD. Text and figures can always be shared among applications, so these are stored in distinct segments of the real object. Application-specific data, such as information describing the application and parameters necessary to read the data, are stored in fusen.

The Standard TRON CPU

One reason why there are efficient implementations of programming languages such as C and Pascal is that compiler companies build their systems according to common specifications and must therefore compete with one another. Multivendor implementations also encourage the wide development of programs written in the common language.

Exactly the opposite situation exists with current CPU architectures, where instruction sets typically have been held proprietary to the particular CPU manufacturer. This situation tends to discourage innovation in future CPU generations because the manufacturer must design its new CPUs to run with its customers' currently operating software.

The TRON project seeks to change this situation and has proposed a standard public domain CPU instruction set that is designed for efficient implementation of the TRON operating system. The current CPU architecture, called CHIP32, provides 32-bit addressing that is upwardly compatible with the 48-bit and 64-bit addressing modes for future CHIP48 and CHIP64 versions. Hitachi has already produced a first-generation version of CHIP32 called Gmicro/200 (see figure 5 and figure 6).

It is important to note that TRON bucks the recent trend toward RISC, headed by the SPARC from Sun Microsystems, and

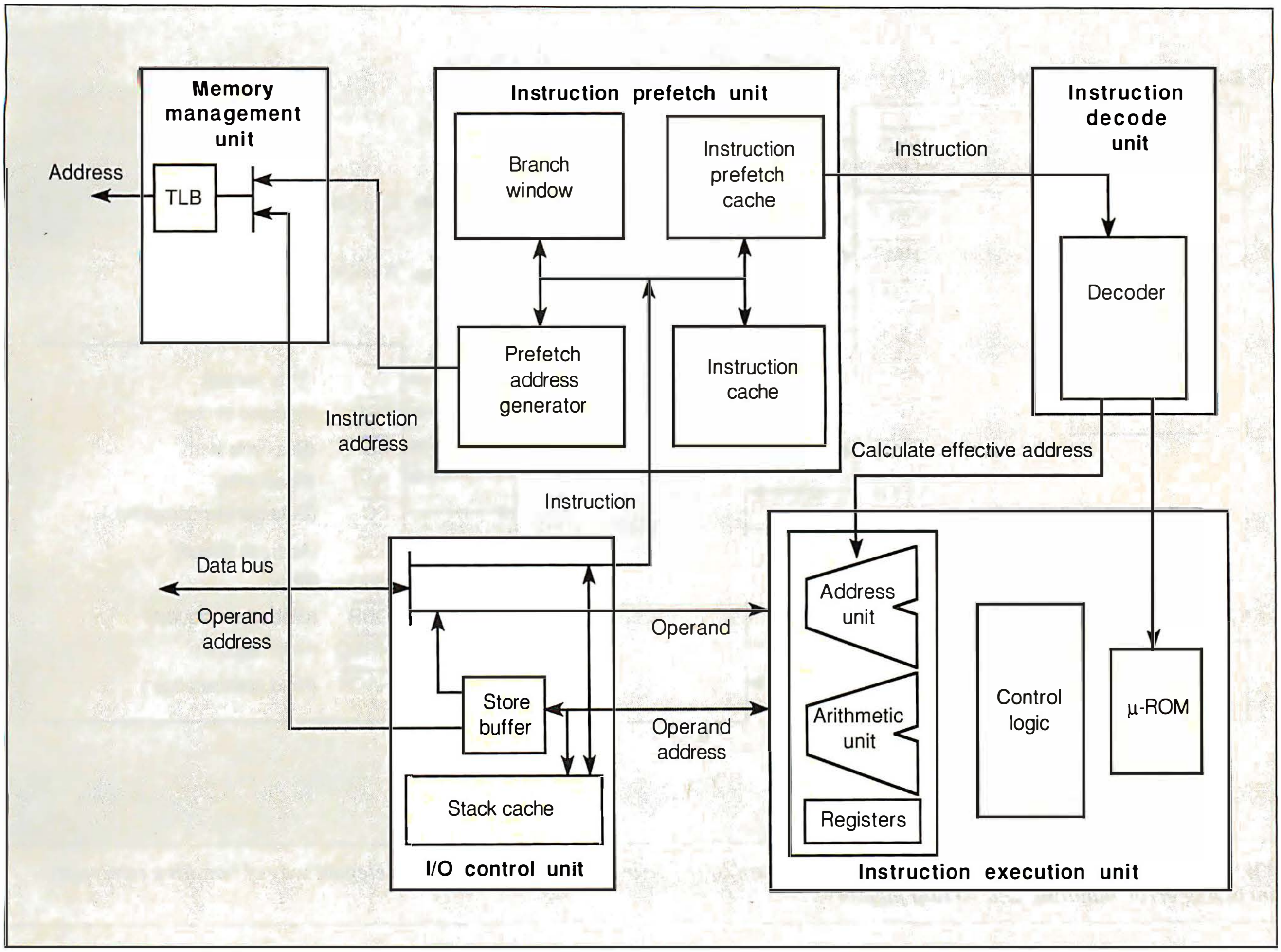


Figure 5: *The Gmicro/200, the first generation of TRON CPUs, provides 32-bit addressing that is upwardly compatible with future 48-bit and 64-bit addressing modes. The internal structure of the Gmicro/200 provides for a very orthogonal instruction set. With the symmetry of operands, you can combine operands in any order.*

similar systems from Hewlett-Packard and IBM. TRON instructions are very high-level, and CPU implementations of the TRON instruction set are among the most complex chips ever designed.

This is not to say, however, that TRON is a traditional CISC (complex-instruction-set computer). On one hand, it includes very high-level instructions designed to be useful for a compiler or an operating system. On the other hand, it has also shaved the length and speed of many of the most common instructions to make it compete favorably with RISC. In other words, it tries to combine the high-speed simplicity of RISC with the programming ease of CISC.

The TRON microprocessor is designed to be a general-purpose processor that is as suitable for high-level workstations as it is for small-scale embedded computers. Excellent performance (as compared to other processors, including RISC) is an important goal, but TRON's general-purpose role allows it to also benefit from easy-to-write and widely available development tools.

Compiler-Oriented Instructions

TRON's instruction set is designed to make it easier to develop high-level language compilers. Wherever possible, the format for operands is kept the same among all instructions, with a minimum of special cases. Memory is treated as one contiguous address space, without segment registers. There are no distinctions between address and data registers, as there are in some processors.

To enable compilers to generate efficient object code, all registers are general registers having the same functions and the same length. Symmetry among instructions makes it much easier to allocate variables and programming work spaces, so TRON's instructions have been made as symmetrical as possible. All 16 general-purpose registers have the same functions, and many restrictions on sizes and available addressing modes have been removed.

In addition, there are two compiler-oriented instruction types not found on other processors: *chained addressing mode* and *arithmetic operations on different data sizes.*

The chained-addressing-mode function generates a complex addressing mode by combining a number of addressing primitives. For example, a sequence of instructions like

```
mov @(8,fp),r1
mov @(r1),r1
mov @(r1),r1
mov @(r1),r1
```

continued

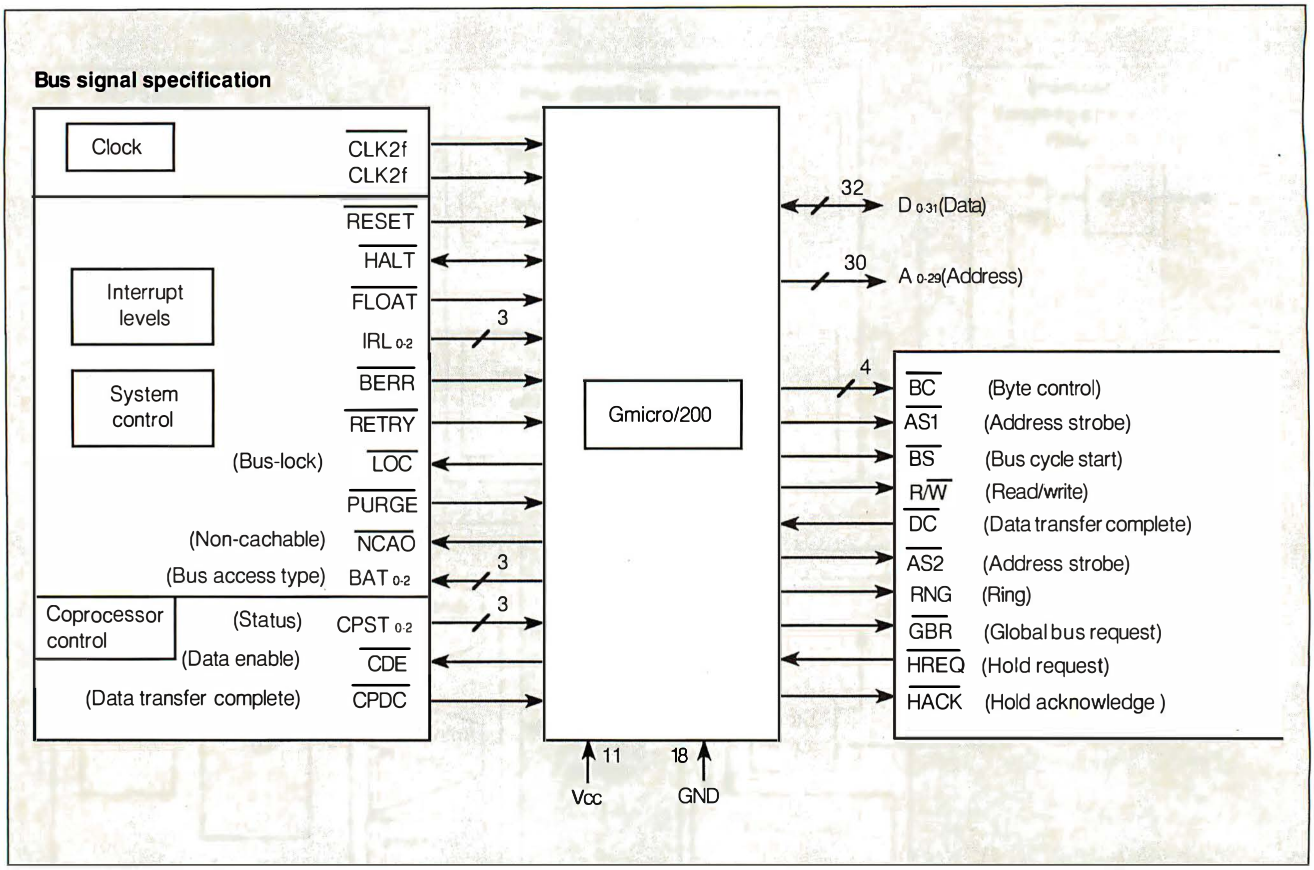


Figure 6: *The bus signal specification for the Gmicro/200. The instruction set permits an elegant way of handling interrupts including error-handling and virtual memory.*

can be replaced by the single instruction

```
mov @(@(@(8,fp))),r1.
```

This feature can be especially effective for referencing between modules.

The arithmetic-operations-on-different-data-sizes function makes operand data symmetrical in size. With this facility, for example, 32-bit data can be multiplied by 8-bit data in a single instruction. This feature can be very useful in compiling a language like C, which frequently converts between data types. A processor without this function needs an additional instruction to expand smaller data to the size of larger data, which, in turn, requires a temporary register and further complicates register allocation in the compiler.

Operating System Support

Typically, CPU instruction sets are designed independently from any operating system. TRON's CPU, however, has been carefully designed with specialized instructions to support both the embedded computer requirements of ITRON and the high-performance workstation requirements of BTRON. There are high-level instructions for context switching (LDCTX and STCTX), for handling queues (QSCH, QINS, and QDEL), bit-map manipulation (BVPAT, BVMAP, and BVCPY), and string instructions (SSCH, SMOV, SCPY, and SSTR).

In other CPU architectures, many of these functions are handled by coprocessors. For example, bit-map functions are often handled by graphics coprocessors. But communication between the main processor and the coprocessor requires a very wide data path, and the resulting overhead can cause performance problems. Since the TRON CPU was designed with its operating system software, there is no need to isolate graphics processing from other functions required by the chip. This makes bit-mapping functions a natural part of the instruction set.

The Implications of TRON

The huge American hardware and software markets have always been big enough that most developers have not considered the international market to be a potential starting point for new hardware and software standards. Japanese domination of the consumer electronics market, and a desire to provide highly functional distributed-systems capability to household products not limited to PCs, has created a standardization vacuum that led to TRON's Japanese origins.

U.S. software companies have already begun to explore TRON's potential as a way to export software to Japan, whose market still lags behind that of the U.S. by several years. Until BTRON, Japanese PC software was mostly limited to programs for MS-DOS-based personal computers (Apple's Macintosh has only 1 percent of the Japanese market). The possibility of a Japanese Macintosh-like competitor should open lucrative opportunities for American companies that are already old hands at designing efficient software that uses windows and pointing devices.

TRON is perhaps the world's most language-independent computer architecture, a situation that should make it much easier to port English-oriented software into Japanese.

Will TRON Succeed?

Janet J. Barron

The TRON concept sounds great: an open architecture that lets users freely shop for chips, components, and peripherals and includes common data-interchange standards that will make everything compatible with everything else. But how will the concept fare in the U.S., and what effect will it have on the computer industry?

John Roach, chairman of Tandy Corp., says that TRON's chances of overtaking the U.S.'s computer industry are very uncertain, although he admits that it's too soon to tell.

"There have been other efforts to develop more viable players, such as the MSX," says Roach. The MSX project was intended to make diverse software programs compatible with low-end home computers from different manufacturers. "Companies were going to make a set of compatible machines. That was the way they were going to attack the world market at the low end," Roach recalls. "That's pretty well gone today."

Besides, anybody who wants to try to build a new operating system is welcome to do so, says Roach. "The development of a new operating system is quite a challenge and takes a very long time. OS/2 is still trying to achieve that critical mass. Unix, I think, is still a relatively important competitor. I doubt that most of us appreciate its full potential. There's a tremendous amount of resources behind U.S. operating systems such as Unix."

About TRON's open architecture, Roach says, "Basically, MS-DOS and Unix are open architectures. Even if TRON becomes successful, it, too, will be limited by the constraints of its past." Since the TRON concept encompasses an open architecture, many domestic companies are deciding whether or not to implement it or to run TRON applications.

Ron Waters, director of Streamlined Instruction Processors at Advanced Micro Devices, suggests that because of the growth of Japanese markets, TRON should be a major success there. With a ready-made educational market of 10 million computers alone, TRON's chances for success in Japan are assured. But, says Waters, "I don't think it will be a success in the U.S."

"Today we have capabilities for embedded processing that are competitive and offer excellent performance. Our innovative microprocessors and software continue to provide superior performance over any TRON chip that could be offered, and we have the capability to run TRON applications without the chips themselves," says Waters.

However, the fact that TRON encompasses VLSI chips, system software, and an open architecture prompted Larry Woodson, a strategist in Texas Instruments's semiconductor group, to say, "It has all the necessary elements for success: Complete software and tools are in development to allow the architecture to be marketed on a worldwide basis. In addition, the Japanese are developing an infrastructure by implementing TRON into some key end products. There is already working silicon and software available, so this is real."

Michael Dell, chairman and founder of Dell Computers, says his firm has no plans to use any of the TRON technology in its next generation of computers. "I don't think TRON will have much impact on microcomputers at this time. In this country, we have an intensely competitive market for microprocessors that drive computers. That market is based around standards that have already been set. As a processor engine, TRON doesn't offer any specific advantages vis-à-vis processors from several of the other major U.S. companies." He added, "There's no basis to suggest the tariff situation will change to make it competitive for Japanese machines."

The Compatibility Question

Meanwhile, Japanese companies such as Mitsubishi, Fujitsu, and Hitachi have already implemented the TRON architecture, a task made easier by the TRON project's specification and standardization of the registers, the I/O, the instruction set, and addressing modes.

According to Charles Glenn, product-line manager for Fujitsu's 32-bit TRON Gmicro microprocessors and peripherals, the TRON project will certify the compatibility of the various implemented architectures with the TRON architecture. In essence, this certification will mean that the architecture can run all the TRON software. Many large Japanese silicon manufacturers endorse this architecture, said Glenn, and thus, "they will make it successful. The merits of the architecture are good."

But according to Jeff Nutt, technical marketing manager for CPUs at Motorola, TRON will not play an important role for at least one reason. "There will be different, and possibly incompatible, implementations by individual companies," says Nutt. "To make its products different from other companies' goods, a firm will do the same thing it does now—it will add its own special features or enhancements. These beefed-up products may be as incompatible as some competitive company's products are right now," Nutt says.

Janet J. Barron is a technical editor for BYTE. She can be reached on BIX as "neural."

TRON's presence is certain to be felt in the emerging educational market created by the Japanese ministry of education's recent announcement that all public schools must use computers. This order creates a market of up to 10 million machines by the mid-1990s. The lack of an easy-to-use Japanese counterpart to MS-DOS should further help its adoption by businesses, in the same way that, in its nascence, Apple succeeded with the Macintosh by creating new markets.

TRON's direct impact on the U.S. PC industry probably won't be felt for several years, although MTRON- and ITRON-compatible home appliances and consumer electronics will be widely available in Japanese-made products much sooner. The fact that it will be easy to connect TRON PCs and TRON products could be an important step in giving TRON a growing share of the 1990s U.S. PC market.

Ken Sakamura, Ph.D., is the founder and director of the TRON project and is an associate professor of information sciences at the University of Tokyo. Richard Sprague has a B.S. in computer science from Stanford University and consults on issues related to the Japanese PC hardware and software markets. He can be reached on BIX c/o "editors" and "rsprague," respectively.

THE IBM PC BIOS

Specialized ROM routines form the heart of a standard

Recently a user on BIX asked some tough questions about IBM PC compatibles. "How can you tell if a clone of the IBM PC is really compatible?" he wanted to know. And, "How do you choose a BIOS for your machine to make it as compatible as possible?"

Alas, there are no easy answers to these questions. But this article—which takes a look inside the IBM PC BIOS—will give you an idea of what goes on inside a typical BIOS. I'll also present some ideas on how to test for compatibility and how to attain compatibility with protected-mode operating systems (which can't use the BIOS).

Perhaps no other single piece of commercial software has been more painstakingly studied, reverse-engineered, and cloned than the IBM PC's BIOS, or basic I/O system. This small set of control programs, which rarely consumes more than 64K bytes even in its most elaborate incarnations, is the key to making a system compatible with the IBM PC family—and to adding new features while retaining compatibility.

Roots: The CP/M BIOS

What is a BIOS? To understand the answer to this question, you must return to the ancient days B.P.C. (before the IBM PC) and look at what was perhaps the first commercially successful microcomputer operating system: CP/M.

CP/M (sometimes called CP/M-80 to distinguish it from other implementations) ran on the Intel 8080 and Z80 microprocessors and had two parts: the BDOS (basic disk operating system) and the BIOS. The BDOS, which was the exclusive property of Digital Research, was the same in every implementation of CP/M, regardless of what hardware it was running on. The BIOS, by contrast, was tailored to the individual machine. The BDOS used the BIOS to access the terminal screen, read and write to the disk, and control the printer; the BIOS, in turn, gave machine independence to the BDOS.

The BDOS source code, as you might expect, was proprietary and was not published. However, the source code for each unique machine's BIOS was frequently available (in manuals, on BBSes, on the Internet network, and so on) so that users could understand and modify it as needed. Any weekend programmer could port CP/M to a new machine simply by creating a set of 17 short BIOS routines (typically only a few K bytes of code) and concatenating them with the BDOS on the disk. Because the relative locations of the BIOS and BDOS were exactly the same in memory as on the disk (one right after the other), they could be loaded together as one large "chunk" when the system was booted. Table 1 lists the original CP/M BIOS functions, and figure 1 shows how the BIOS and BDOS were laid out in RAM. The BIOS functions were entered through a *jump table* (a list of jump instructions).

The IBM PC, PC-DOS, and the ROM BIOS

One of the few problems with concatenating CP/M's BIOS and BDOS on the same disk was that you couldn't start one brand of machine from a disk intended for another (even if the disks were in the same format). When IBM adopted Microsoft's MS-DOS (derived from a CP/M look-alike called 86-DOS) as the primary operating system for its early PCs, it avoided this problem by moving the BIOS to a ROM within each machine, creating the new memory arrangement shown in figure 2. The result—at least in theory—was a system in which disks could be freely exchanged between radically different types of hardware.

This approach might have been completely successful had early versions of the BIOS been highly optimized and fully featured in all areas. The IBM PC BIOS's disk functions, for instance, were quite fast, and programmers saw little need to bypass them. However, the BIOS screen functions in the original PC were slow, and some calls, such as those that controlled serial communications, were barely useful at all. In a few areas (e.g., sound), BIOS support was even lacking on the original PC. In these areas, programmers were forced to write code that manipulated the hardware directly.

Also, many programmers made use of memory locations used internally by the BIOS—locations that IBM was forced to maintain to keep new hardware compatible with the established software base. The result was a de facto "hardware/software" standard—consisting of BIOS calls, directly mapped storage locations, and peripheral hardware addresses—that remains prevalent to this day. While not as hardware-independent as IBM might have wished, this standard *has* been successful, and it has been implemented on a wide variety of machines, including laptops, diskless workstations, and even IBM's Micro Channel computers, which among compatibles represent some of the greatest departures from the original IBM PC architecture.

The ROM BIOS Services

The functions of the IBM PC ROM BIOS fall into several categories, each handled by its own software interrupt (see the text box "Software Interrupts and the 8086" on page 307). These categories include video, machine configuration, memory size determination, disk operations, serial communications, miscellaneous functions, keyboard control, the printer, invocation of BASIC in ROM (if present), bootstrapping the system, and system

continued

timer functions. (Other services, such as expanded memory and NetBIOS, are also activated via software interrupts but are not, strictly speaking, part of the main BIOS.)

Once the software interrupt for a particular category of functions has been invoked, the AH register—a byte-wide register within the 8086 CPU—is examined to determine the specific task to be performed. The other CPU registers hold additional information to be passed to the BIOS function. Since registers, rather than the stack, are used to pass information to the BIOS routines, the information transfer is especially quick.

Table 2 gives a summary of the major BIOS services, grouped by function and software interrupt.

Video—INT 10h

The first BIOS software interrupt, INT 10h, controls the PC's video display. It allows you to put the display into text or graphics mode; select the number of characters, pixels, and colors that appear on the screen; move the cursor; scroll the screen; plot pixels; and read or write characters. The EGA, PGA, VGA, and 8514 display adapters contain their own ROMs, which enhance and supersede the functions of the original BIOS ROMs; the enhanced functions allow application programs to select fonts, print the screen on the printer, change the color palette, and perform other graphics functions.

IBM later streamlined the video BIOS and added more functions (e.g., the AT has a function that can write more than one character to the screen at a time). But programmers couldn't wait for these enhancements to come along; they needed to have their programs run on *every* system, and they wanted more speed than they could get through the BIOS routines. They therefore adopted the practice of bypassing the BIOS and writing directly to the PC's memory-mapped screen. Because it is so common, this approach will work on virtually all compatible machines. However, in multitasking and windowing environments such as DESQview, programs that perform direct screen writes—often called "ill-behaved" programs—may not be able to share the screen gracefully with others. The Intel 80386's "virtual 8086" mode may help to contain such programs and force them to be "cooperative" in a multitasking environment, but the 80286 has no such mode. This is why the OS/2 compatibility box can currently run only one DOS application at a time.

Table 1: *CP/M BIOS functions. These 17 routines, shown as they were arranged in the BIOS jump table, were all that were needed to adapt the CP/M-80 operating system to a new machine.*

Jump table location	Name	Function
0	BOOT	Cold bootstrap.
3	WBOOT	Warm bootstrap.
6	CONST	Console (terminal) status.
9	CONIN	Console input.
12	CONOUT	Console output.
15	LIST	List device (printer) output.
18	PUNCH	"Punch" (paper tape) output.
21	READER	"Reader" (paper tape) input.
24	HOME	Move disk head to track 0.
27	SELDSK	Select a disk to read/write.
30	SETTRK	Set the disk track to read/write.
33	SETSEC	Set the sector to read/write.
36	SETDMA	Set memory location for disk data.
39	READ	Read a sector.
42	WRITE	Write a sector.
45	LISTST	Status of List device.
48	SECTRAN	Translate logical sector number to physical.

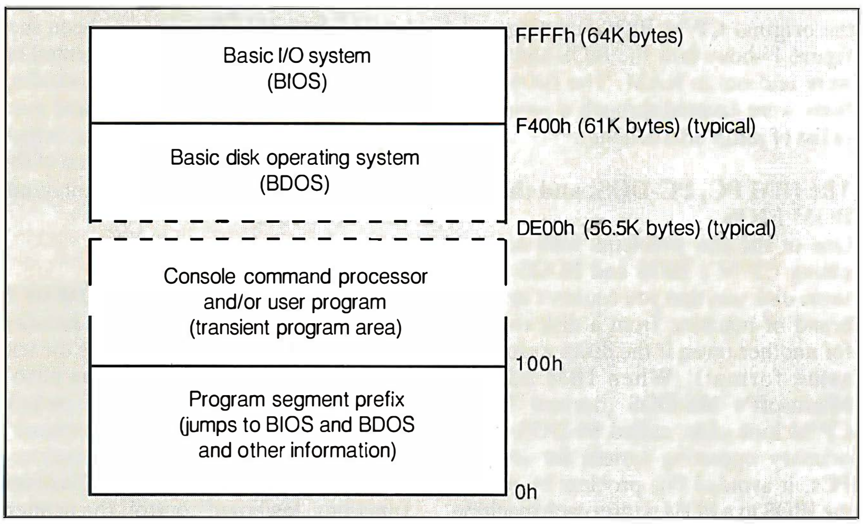


Figure 1: *In CP/M, the BIOS loaded from disk together with the BDOS in a single chunk. Both resided in high memory above the user program.*

Equipment Status—INT 11h

This software interrupt has only one function: to return information on the equipment attached to the PC. It returns a 16-bit word whose bits contain this information, as shown in figure 3.

Memory Size—INT 12h

This software interrupt also has only one function: to return the size of the computer's RAM (in K bytes) in the AX register. Extended memory (the memory above 1 megabyte) isn't included in this number.

Disk Operations—INT 13h

The INT 13h interrupt controls disk operations. Unlike the original CP/M BIOS, the IBM PC BIOS has a set of disk functions complete enough to eliminate the need for hardware-specific utilities. This has allowed the development of a wide variety of add-on disk controllers for the IBM PC; had there been a need to bypass the BIOS, it wouldn't be possible to add a new type of disk simply by adding a BIOS extension ROM.

Interestingly, the AT disk BIOS did not support some functions listed in the documentation for the XT; these may have been intended for use with SCSI drives (which IBM has never sold for the PC line).

Serial Communications—INT 14h

The serial communications functions of the IBM PC BIOS are, alas, among its weakest points. Unlike all but the most basic communications programs, the BIOS serial routines do not use hardware interrupts to receive characters from external serial devices. This means that characters are likely to be "dropped" if a program on the PC does not constantly watch for their arrival.

As a result, virtually every program that uses the serial port (with the possible exception of print spoolers, which rarely receive characters) takes over the communications hardware and controls it directly.

Cassette/Joystick/Multitasking—INT 15h

Software interrupt 15h controlled the cassette tape interface and joystick port on the original IBM PC. However, since this interrupt was rarely used (the cassette interface was dropped entirely on the AT), IBM added new INT 15 functions, including support for multitasking, peripheral sharing, switching to protected mode, and detecting the use of the System Request key on the AT keyboard. The multitasking support functions are used only by some network programs, and OS/2 implements a faster mode switch than the standard BIOS does, so many of these functions are rarely invoked.

Keyboard—INT 16h

Software interrupt 16h manages the IBM PC's keyboard. Keystrokes are returned as both ASCII characters and "scan codes"—codes directly related to the position of each key on the keyboard. Scan codes can help a program distinguish between two keys that send the same ASCII characters—for instance, the + key on the main keyboard and the + key on the numeric pad.

BIOS keyboard functions are sometimes bypassed by utilities, like SuperKey, that remap the keyboard or enable and disable specific key sequences. Most application programs, however, use the keyboard as is.

Printer—INT 17h

This software interrupt provides three simple printer functions. It can initialize the printer port, check the printer status, or output a character to the printer.

BASIC—INT 18h

Most PC compatibles don't implement a BASIC in ROM, as IBM PCs do. However, on machines that *do* have a BASIC, software interrupt 18h starts it running.

Bootstrap—INT 19h

Software interrupt 19h reboots the PC. Since this interrupt causes a "warm" boot, the BIOS doesn't test memory; however, it does scan for ROMs containing extensions to the BIOS, as I'll explain shortly.

System Timer—INT 1Ah

Software interrupt 1Ah allows a program to set and get the system time (measured in *ticks*). A tick occurs roughly 18.2 times per second, so there are exactly 65,536 ticks in an hour. On the AT, the

continued

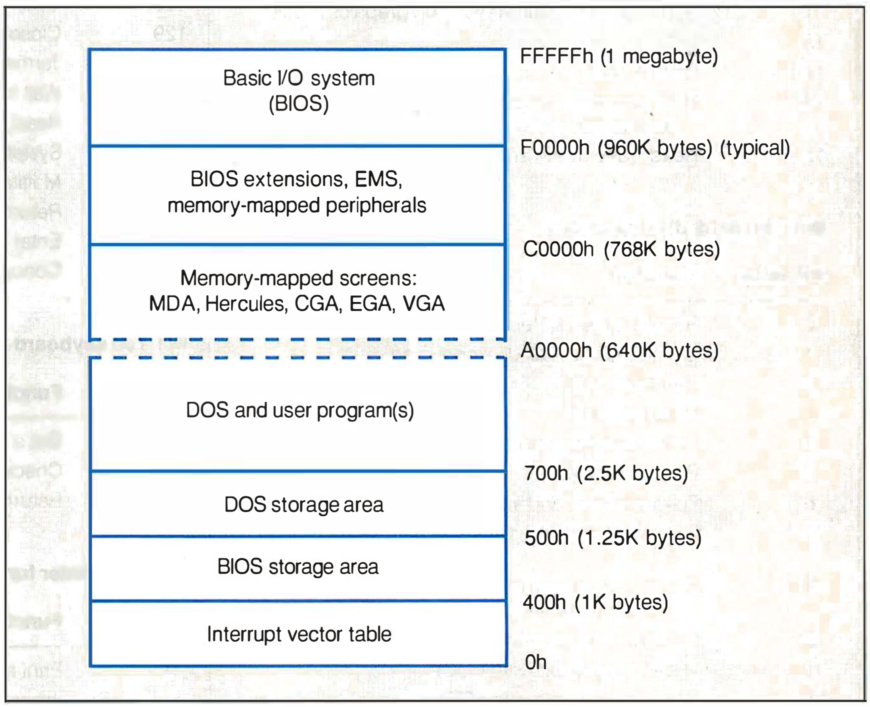


Figure 2: *In the IBM PC, the high end of the memory-address space is reserved for the ROM BIOS, memory-mapped video, BIOS extension ROMs, memory-mapped peripherals, and expanded memory. The interrupt vector tables, BIOS storage area, DOS storage area, and DOS itself occupy the low end of memory. The user program loads between DOS and the memory-mapped screen area. Note that this memory layout gives rise to the infamous "640K barrier" that EMS, OS/2, and 80386 memory managers attempt to circumvent.*

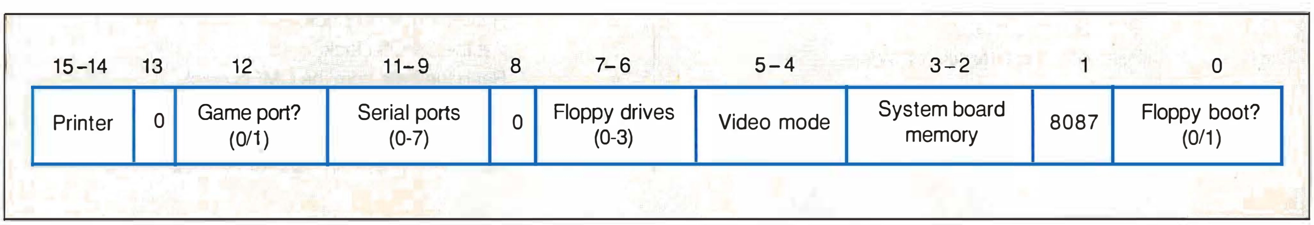


Figure 3: *The equipment configuration word, returned by the equipment status BIOS call, gives basic information on how the PC is equipped.*

Table 2: *Major IBM PC BIOS services.*

INT 10h BIOS video functions

AH value	Function
0	Set video mode (0-6 for CGA, 7 for monochrome).
1	Set cursor shape (starting and ending lines).
2	Move the cursor.
3	Read cursor location and shape.
4	Read position of a light pen (seldom used).
5	Switch "pages" of display in text mode.
6	Scroll up.
7	Scroll down.
8	Read character and attribute at cursor.
9	Write character and attribute at cursor.
10	Write character at cursor.
11	Set color for medium-resolution graphics modes.
12	Write a pixel.
13	Read a pixel.
14	Write character to screen with rudimentary terminal emulation.
15	Read video mode and page.

INT 13h BIOS disk functions

AH value	Function
0	Reset the disk system.
1	Get status from last disk operation.
2	Read sector(s).
3	Write sector(s).
4	Verify sector(s) against memory.
5	Format a track.
6	Format a track and flag bad sectors (not on AT).
7	Format drive starting at a specified sector (not on AT).
8	Return parameters of current drive (heads, cylinders, sectors).
9	Initialize drive characteristics.
10	"Read long" (read with ECC).
11	"Write long" (write with ECC).
12	Seek to track.
13	"Alternate" disk reset.
14	Read sector buffer (not on AT).
15	Write sector buffer (not on AT).
16	Test if drive is ready.
17	Recalibrate the drive.
18	Controller RAM diagnostic (not on AT).
19	Drive diagnostic (not on AT).
20	Controller diagnostic.
21	Read drive type (fixed, floppy).

INT 14h BIOS serial communications functions

AH value	Function
0	Initialize a serial port.
1	Send a character.
2	Receive a character.
3	Read serial port status.

INT 15h cassette and multitasking functions

AH value	Function
0-3	Cassette functions.
4-127	Not used.
128	Open a shared device.
129	Close a shared device.
130	Terminate a task/program.
131	Wait for an event.
132	Read joystick position/switches.
133	System Request key.
134	Multitasking "wait" function.
135	Return size of AT extended memory.
136	Enter protected mode.
137-138	Concurrent I/O for multitasking systems.

INT 16h keyboard functions

AH value	Function
0	Get a keystroke.
1	Check for available keystroke.
2	Return status of Shift keys.

INT 17h printer functions

AH value	Function
0	Print a character.
1	Initialize the printer port.
2	Return printer status.

INT 1Ah time functions

AH value	Function
0	Read the system time.
1	Set the system time.
2	Read the CMOS clock.
3	Set the CMOS clock.
4	Read the date from the CMOS clock.
5	Set the date in the CMOS clock.
6	Set the "alarm" in the CMOS clock.
7	Reset the "alarm" in the CMOS clock.

time and date in the CMOS clock chip can also be written and read via this interrupt, and an "alarm" can be set to go off at a specific time.

Most current software does not use INT 1Ah to access the PC's real-time clock but inserts a service routine into a chain of routines called by interrupt 1Ch each time the timer ticks. Programs must be careful to remove themselves from this chain before terminating to avoid system crashes.

Bringing Up the System: POST and ROM Scan

Besides providing user-callable services, the ROM BIOS also performs general maintenance functions on the PC. When the system is first powered up, the BIOS performs a thorough check of the CPU, RAM, and ROM; it also looks for stuck keys on the keyboard and disk functions. Few parts of the PC escape scrutiny; if the power-on self test (or POST) is successful, it's likely that the machine is ready to boot.

After the POST, the ROM BIOS performs a function known as ROM Scan. The beginning of each 2K-byte block of memory between locations C8000 and E0000 is checked for a special signature; if the signature is found, the BIOS performs a checksum and executes a ROM at that location. This is the way peripheral board makers create "BIOS extensions" to accommodate new peripherals—a ROM on the board can initialize the peripheral, make it accessible via preexisting BIOS calls, and/or even interact with the user. This simple feature is one of the touches that make the IBM PC architecture truly "open" to peripheral vendors.

BIOS Variables

The area of PC memory from location 40h to location 50h contains storage locations that are reserved for use by the BIOS. While this area was not originally intended for use by application programmers, certain locations were so frequently accessed by user programs that IBM was forced to "freeze" their implementation to ensure compatibility with future machines. The information contained in the BIOS storage area includes:

- The number and locations of serial and parallel ports
- Equipment information (also accessible via INT 11h but frequently accessed directly)
- The keyboard queue
- Disk status information
- The system clock (often read directly instead of through INT 1Ah)
- Information on the current video mode and cursor position

Many reference books now describe these locations in detail (see the bibliography).

Compatibility

One of the most common questions asked by prospective buyers of IBM compatibles is "How compatible *is* it?" (See the text box "The 'Clean Room' Approach" on page 308.) Alas, because the "standard" for compatibility is at best an ad hoc one, there is no easy answer to this question. Because it can, in many cases, hide hardware differences, the compatibility of the BIOS is one of the most important factors in determining the compatibility of the entire machine. But since software often bypasses the BIOS and accesses the hardware directly, a well-coded BIOS is not a 100 percent guarantee of compatibility.

How do you test for compatibility? Traditionally, the standard measures of IBM compatibility have been badly behaved application programs. According to Samuel Adams Yorko, a BIOS compatibility expert, these programs include Microsoft's Flight Simulator, Lotus 1-2-3, XenoCopy, Microsoft Windows, Microsoft Word, Microsoft QuickC, DESQview, and early versions of Novell NetWare. TSR programs are excellent tests of compatibility. Copy-protected software, in its zeal not to be copied, tends to be quite finicky, and games in particular are good benchmarks because they cut corners to push the hardware and software to their performance limits.

Interestingly, as BIOSes have become more compatible, programs have also be-

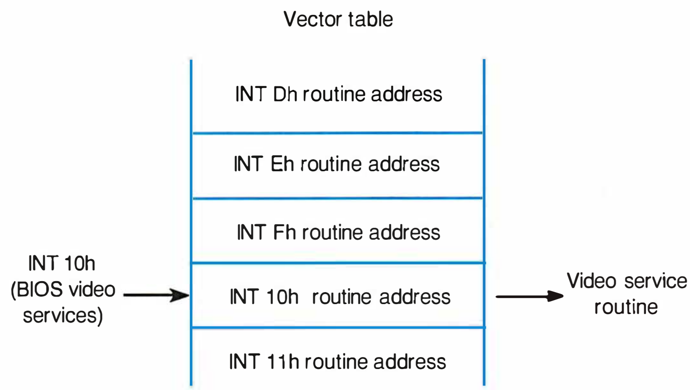
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Software Interrupts and the 8086

The IBM PC BIOS routines are called via 8086 instructions called *software interrupts.* Each instruction, represented by the mnemonic INT, carries a 1-byte interrupt number from 0 to 255 (FF hexadecimal). The interrupt number is an index into a *vector table,* a table in memory containing the 4-byte address of the service routine for each interrupt. In figure A, an INT 10h instruction is used to call a BIOS video routine.

Most of the INT. instructions are 2 bytes long, but one of them—INT 3—also contains a special single-byte encoding. You can take advantage of this variant when debugging or as a quick 1-byte subroutine call.

Figure A: *The number in an INT (software interrupt) instruction is used to find the address of an interrupt service routine in the 8086's interrupt vector table. In the IBM PC, this table normally starts at the very bottom of memory, with the INT 0 vector at location 0, INT 1 at location 4, and so on.*



The "Clean Room" Approach

Makers of IBM PC compatibles have long feared lawsuits from Big Blue—especially after IBM was said to have threatened legal action against fledgling Eagle Computer for copying parts of the IBM PC BIOS. Amid the uncertainty and confusion that prevailed in 1983, Phoenix Technologies consulted lawyers and came up with a technique for creating a "legal" IBM-compatible BIOS: the so-called "clean room" approach.

First, Phoenix assembled two teams of programmers. The first became thoroughly familiar with the IBM BIOS and wrote a detailed specification explaining what the BIOS had to do to be compatible. A second team, consisting of programmers who swore they had never seen a copy of the IBM PC BIOS, created a BIOS from that specification and sent it back to the first team. The first team checked the BIOS for compatibility and then modified the specification to cover areas that were missed on the first pass. All information that was exchanged by the two teams was monitored and recorded in the event of legal action.

After many cycles, the "clean" team (the programmers who had never seen the actual IBM BIOS) was able to produce a set of ROMs that was nearly 100 percent compatible with IBM's. Because these programmers had never seen the original IBM code, but only a description of how it worked, Phoenix was confident that IBM would not be able to sue for copyright infringement.

To bolster this claim, Phoenix persuaded an insurance company to underwrite a "BIOS insurance policy" that would protect BIOS licensees from legal costs incurred in the event of an IBM lawsuit. While no policy was ever written, Phoenix's customers were apparently convinced that the approach was sound: There are more compatibles with Phoenix BIOSes than there are genuine IBM PCs in use today. Furthermore, despite questions regarding the originality of "clone" hardware designs, the originality of Phoenix's software has never been challenged in court.

come more well behaved. Newer versions of the programs mentioned above now run on more machines than ever, and the demise of copy protection has removed one of the major barriers to compatibility. Nowadays, it's relatively safe to assume that if a system runs a reasonable selection of TSRs, multitasking environments (e.g., OS/2, DESQview, Windows), and applications, it will be compatible with most other software. This convergence is due, in part, to economic necessity; because there are far more clones than there are "genuine" IBM PCs in the marketplace, it's in every software manufacturer's best interest to test products with the major compatible BIOSes (e.g., Phoenix, Compaq, AMI, and Award) before release.

Building Your Own BIOS

At one time, the art of building a compatible BIOS was shrouded in so much mystery that few dared to attempt it. At long last, though, those days appear to be over; dozens of books have now been published giving detailed information on the "innards" of the IBM PC BIOS. In fact, one—which arrived on my desk last week—gives the complete source code for an AT BIOS, largely written in C!

This book is worthy of special mention because of its novelty. *XT and AT BiosKits* from Annabooks (see bibliography) lets you create and customize a BIOS using only a C compiler, an assembler, and an EPROM programmer. Within an hour of assembling the required tools, I was able to burn a set of EPROMs and install them in my AT clone. As far as I could tell, the BIOS was fully compatible, and I was able to patch it to understand a new type of hard disk (not included in the standard tables) in only a few minutes. Other forms of "surgery" were equally straightforward. The Annabooks BIOS includes a resident monitor called SysVue that lets you peek at what's going on inside the system at any time—very handy for debugging the BIOS itself as well as other programs.

The Annabooks code is reasonably well commented, and it comes with a little gem that's very useful for PC-family programmers: the *XT-AT Handbook*. This pocket-size reference book is packed with information on DOS commands, the PC character set, I/O port addresses, interrupt vectors, RS-232C pinouts, and the PC hardware in general.

The literature that comes with the BIOS kit says that the authors will license the BIOS for use by any compatible manufacturer for $4 a copy. At that price, they may get a lot of takers.

Exploring an Existing BIOS

If your hardware is close to 100 percent compatible with the IBM PC or AT, it's likely that many manufacturers' BIOSes (including IBM's, if you are able to get hold of some original ROMs) will run on it with no modifications. However, if your computer's architecture differs significantly from that of the IBM PC and AT, and you want to make BIOS modifications (or just see how it works), you may need to disassemble the existing code. Also, because IBM no longer provides BIOS source code in its *Technical Reference* manuals, disassembly may be the only way you'll be able to get a look at what's going on inside the BIOS.

One painful but time-honored method of peeking into a BIOS is to trace through it with a debugger. DOS's DEBUG command will work for some of the less esoteric sections of the code; I've successfully used it to follow and understand the BIOS serial port services, for instance. But to trace through interrupt service routines and nonreentrant parts of the code, you'll need an in-circuit emulator—or a board like Atron's PC Probe, which performs a similar function.

Another less expensive approach is to purchase a disassembler explicitly designed to handle BIOSes. I recently used a product called Sourcer, made by V Communications of San Jose, California, to examine the BIOS of a PC-compatible coprocessor board with reasonably good results.

Sourcer, which can also disassemble standard .EXE and .COM files, comes with a very clever preprocessor that captures the BIOS *as it's running* on a machine. Besides looking at the code in the ROMs, the BIOS preprocessor looks in low memory for software and hardware interrupt vectors that point into the BIOS—identifying key entry points that might not be found otherwise. The preprocessor also takes snapshots of key variables within the BIOS's data area, so you can see the same values that the BIOS code might see while running. Everything the preprocessor identifies is neatly labeled in the disassembly listing.

No disassembler is perfect, though, and you'll probably find places where the disassembler mistook code for data (or the other way around). You can put the

disassembler back on track by modifying a control file to give explicit information about that area of the ROM.

At $140, Sourcer with the BIOS preprocessor is a reasonably priced learning tool as well as a programmer's lifesaver. Just looking at the disassembled BIOS code is a real education and is highly recommended for the inquisitive.

ABIOS

The IBM PC BIOS is able, in many cases, to isolate programs that run in the "real" mode of the 8086 family of processors from the physical hardware—especially in certain areas such as disk I/O. However, it has few provisions for handling memory sizes greater than 1 megabyte and little support for the protected modes of the 80286 and 80386 processors. Thus, an environment that uses protected mode to multitask or to break the 640K-byte barrier on a standard AT compatible is forced to take one of two approaches: It can switch the processor back to real mode (slowly!) to use the IBM PC BIOS calls, or it can go directly to the hardware in protected mode, sacrificing the hardware independence provided by the BIOS.

To avoid this problem, IBM has come up with a new kind of BIOS: the Advanced BIOS, or ABIOS. (IBM sometimes calls the older, real-mode BIOS by the name CBIOS, or Compatibility BIOS, to distinguish it from the ABIOS.) ABIOS, which is currently implemented only on IBM's PS/2 series and compatibles, can be used by operating systems running in either real mode or protected mode—or by "bimodal" environments, like OS/2, that switch back and forth. ABIOS provides even greater isolation from the physical hardware than the original CBIOS and contains complete support for concurrent device access by many processes in a multitasking system.

Types of ABIOS Requests

ABIOS can support three types of requests made by an operating system or a user program: *single-staged*, *discrete multistaged*, and *continuous multistaged*. Each type of request is diagrammed in figure 4.

In a single-staged request, the ABIOS performs the requested function right away; it's done by the time the program regains control. A discrete multistaged request happens in two or more stages, with delays between the stages; the calling program regains control during the delays so that other processing can be done. A continuous multistaged request starts a staged operation that never ends.

Calling ABIOS

The ABIOS calling conventions reflect the needs of protected-mode and bimodal operating systems. ABIOS, unlike CBIOS, is entered by far calls rather than by software interrupts and is completely reentrant even between modes. That is, a real-mode function X can be interrupted and a protected-mode function Y started, even if X is identical to Y.

When a program or operating system calls ABIOS, it must pass pointers to two structures: a request block and a common data area (see table 3). The request block specifies the function to be performed—just as the interrupt number, the AH register, and the other CPU registers tell the CBIOS what needs to be done. The common data area, ABIOS's "master switchboard," is a table that contains pointers to all of ABIOS's other tables and data areas.

The internal data structures linked together by the common data area include function transfer tables—which, like CP/M's jump tables, list the addresses of routines that perform certain functions—and device blocks, which contain public and private information used by devices. The details of these complex structures can be found in IBM's *Personal System/2 Seminar Proceedings* (see bibliography).

When a program calls ABIOS, it must provide the segment or selector of the common data area and a pointer to a request block. Two other parameters may or may not be furnished by the caller, depending on the convention used. In the ABIOS Transfer Convention, ABIOS accepts just the addresses of the request block and the common data area and finds a function transfer table and a device block to use when handling the request. In the Operating System Transfer Convention, the caller furnishes the locations of these data structures. Note that since the parameters are not removed from the stack upon return to the caller, an operating system can save the function transfer table and device block addresses after they have been furnished by ABIOS during a call.

Interrupt Handling in ABIOS

Unlike CBIOS, ABIOS expects system devices to share interrupts. In a machine running under ABIOS, the operating system—not ABIOS—gets control when a hardware interrupt occurs. It is the responsibility of the operating system to call ABIOS to have the interrupt serviced, and the operating system must also issue the End of Interrupt command to the interrupt controller.

continued

Table 3: *ABIOS stack frame and calling conventions.*

Bytes	Stack contents
2	Common data area pointer (segment/selector only)—required.
4	Request block pointer—required.
4	Function transfer table pointer—furnished by ABIOS or caller.
4	Device block pointer—furnished by ABIOS or caller.
4	(Return address.)

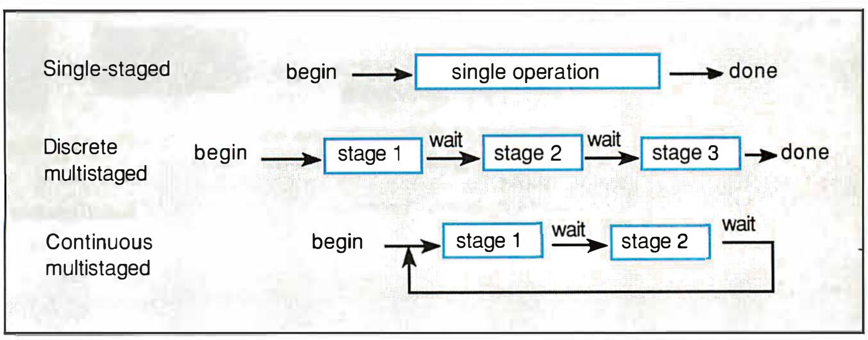


Figure 4: *ABIOS request types. A single-staged ABIOS request completes immediately before returning to the caller. A discrete multistaged request is processed in stages with delays between the stages; control is returned to the caller until a hardware interrupt signals that a stage has completed. A continuous multistaged request starts a process—sometimes called a daemon—that loops forever between one or more stages.*

If more than one device is sharing a hardware interrupt, the operating system must invoke the ABIOS interrupt handling routine for each of these devices in turn. If the current interrupt does not affect a device, the operating system receives a return code from ABIOS that says, "This is not my interrupt; please try another device." The operating system continues to query devices until one responds to the interrupt request.

Future Compatibility

ABIOS is an important step toward maintaining machine independence in the Intel protected-mode world. Unfortunately, the majority of PC compatibles available today—and likely to be available in the near future—do not have ABIOS, and users of multitasking operating systems such as OS/2 and Unix must buy machine-specific versions of the operating system and/or install device drivers to adapt the operating system to each machine.

There is no compelling technical reason, however, why ABIOS cannot be added to existing systems—as an add-in ROM or even as a TSR. (In fact, IBM has stated publicly that "ABIOS is contained in ROM but does not preclude a RAM implementation.") It is to be hoped that, in the long term, compatible manufacturers (and/or enterprising software designers) will provide ABIOS implementations for existing 80286 and 80386 machines. If this does happen, you can anticipate an even greater level of standardization and machine independence than that engendered by the original IBM PC BIOS.

In the meantime, the venerable IBM PC BIOS—now well understood and readily implemented—has fostered the development of a strong, consistent industry standard. While far from perfect, this standard will doubtless persist for another decade or more and will allow manufacturers to produce quality products at commodity prices. Hopefully, newer standards, such as ABIOS, will eventually replace the standard CBIOS as the basis for compatible machines with multitasking and more than 640K bytes of directly addressable memory. Only time will tell if these new standards will ever be as pervasive as the standard that lies at the heart of the IBM PC. ■

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 Rick Grehan

FLOATING-POINT REVISITED

This variation on a theme yields a floating-point package particularly suited to business applications

Floating-point is a topic of sufficient significance for me to cover it more than once, particularly when there's some ground that I didn't cover last time (see my two-part "Floating-Point without a Coprocessor" in the September and October 1988 BYTE). This month's package is fundamentally different from the previous one—it has strengths where the other has weaknesses, making it particularly suited to business and accounting applications.

The floating-point package that I described in "Floating-Point without a Coprocessor" manipulated floating-point numbers in base 2; such numbers are called binary floating-point numbers. This time, I'm presenting a binary-coded-decimal (BCD) floating-point package. As you'll see, BCD floating-point computing has some advantages over binary foating-point computing. (Borland includes a BCD option in its Turbo Pascal programming language, and Zedcor uses a BCD representation for floating-point numbers in its ZBasic compiler.)

But it's not all roses. There are some disadvantages to using BCD floating-point numbers. That's part of life in the computer world. This column should help you decide which form—BCD or binary—is best for your applications.

Inside

I can describe the format of a BCD floating-point number easily. (You'll catch on even quicker if you've read my earlier article on floating-point.) Take a look at figure 1 and see if you recognize the structure. FAC1_EXP holds the exponent, FAC1_SIGN contains the sign of the number, and FAC1_MAN holds the mantissa.

The main difference between a binary floating-point number and a BCD floating-point number is that the binary number is in base-2 representation while the BCD number is still in base 10. A binary floating-point number looks like this:

$$\pm a \times 2^b$$

where a is the mantissa and b is the exponent. In the case of most floating-point formats in use today (e.g., the IEEE formats and the one I presented in "Floating-Point without a Coprocessor"), a is interpreted as a binary fraction, and b is an integer.

In contrast, a BCD floating-point number has the following form:

$$\pm a \times 10^b$$

Now, a is a decimal fraction in BCD notation; b is still an integer, but this time it indicates a base-10 exponent. But how is a number stored in BCD notation? The process is simple: Take each decimal digit in the number, convert that digit into its 4-bit binary equivalent, and store each 4-bit packet into successive nibbles of the BCD number. So, 32 base 10 would be 00110010 base 2; 458 base 10 would be 010001011000 base 2.

Actually, I'm being needlessly difficult. If you convert a base-10 number into its BCD equivalent and display the results in hexadecimal, it looks just like the original number. So, 458 base 10 converted to a BCD number and displayed in base 16 is just 458. Each decimal digit is stored in 4 bits—exactly the number of bits required to store a hexadecimal digit. (This is particularly nice when you're in a debugging session: You can determine a BCD floating-point number's value on sight. Try that with a binary floating-point number!)

In my September column, I introduced the idea of a *bias* in regard to the exponent. You can think of the bias as an offset that allows the exponent to represent both positive and negative values. This BCD floating-point package uses a bias of 16384; the true value of the exponent is FAC1_EXP − 16384. This translates to a range of ± 16383 for the exponent. An exponent of 0 is a special case that indicates true zero, allowing routines to test for zero by looking at a single word rather than having to scan the entire contents of the mantissa.

So what do all these attributes buy you? First, since the BCD floating-point number is in base 10, you don't lose any precision when converting numbers between their external form (ASCII strings on the display) and their internal representation. As a contrasting example, the binary equivalent of 0.1 is a repeating binary fraction, just as the decimal number for ⅓ is 0.333333. . . . Consequently, 0.1 cannot be precisely converted into a binary floating-point number. Happily, BCD floating-point numbers do not suffer from such rounding errors: 0.1 is easily stored as a BCD floating-point number with no precision loss. On the other hand, BCD floating-point numbers suffer from truncation errors: The number is simply snipped off at the least-significant digit.

Another drawback to using BCD floating-point numbers is that the four basic arithmetic routines are slower than their binary counterparts. This is because you can't use the base number system native to the machine (base 2). Designers of the 8088 (and other popular CPUs) have incorporated special instructions for working with BCD numbers, but these instructions tend to be, shall we say, less robust than their binary counterparts. BCD instructions operate on byte-size quantities only, so you can-

continued

Listing 1: *Pseudocode for BCD floating-point addition and subtraction.*

```
{ Add the contents of FAC1 to the contents of FAC2. The result is
{ returned in FAC1.
FADD:
  IF FAC2_EXP > FAC1_EXP THEN
   Swap FAC1 and FAC2;
  N := FAC1_EXP - FAC2_EXP;
  { N is the difference between the two exponents; i.e., the number
  { of times we have to multiply FAC2 by 10. This multiplication is done
  { by shifting, and if we have to shift more times than there are
  { digits, the number is already in FAC1.
  IF N > NUMBER_OF_DIGITS THEN
     RETURN no error;
  REPEAT N TIMES
   SHIFT FAC2_MAN right 1 nibble;
  IF FAC1_SIGN = FAC2_SIGN
   { The following is a BCD addition.
   FAC1_MAN := FAC1_MAN + FAC2_MAN;
  ELSE
   BEGIN
     { The following is a BCD subtraction.
     FAC1_MAN := FAC1_MAN - FAC2_MAN;
     IF borrow occurs THEN
      BEGIN
        FAC1_SIGN := FAC1_SIGN XOR 80H;
        { The following step may only be necessary on the 80x86 family-
        { thanks to the way it performs BCD operations. To negate the
        { mantissa, set the carry and perform a BCD subtraction from 0.
        Negate FAC1_MAN;
   END
  GOTO NORM_FAC1;
{ Subtract contents of FAC2 from contents of FAC1. Result in FAC1.
FSUB:
  FAC2_SIGN := FAC2_SIGN XOR 80H;
  GOTO FADD;
```

not take advantage of a 16- or 32-bit register. In contrast, a binary floating-point package written specifically for an 80386 or 68000 would perform approximately half the register-to-memory fetches than would an equivalent BCD package on, say, an 8088.

There is a final saving grace for BCD. As I've mentioned, I/O of BCD floating-point numbers is tons simpler and quicker than I/O of binary floating-point numbers. If you review "Floating-Point without a Coprocessor," you'll see that the input and output routines have to perform floating-point multiplication and division by 10; they're time-consuming operations. With BCD floating-point numbers, I/O isn't much more than a series of shift and mask operations. No multiplications are involved.

Addition

You may recognize the similarity between these algorithms and the ones that appeared in my previous discussion of floating-point; if not, you should still have no trouble following the discussion, thanks to the fact that this BCD package lets you work in base 10. These routines use a set of floating-point accumulators (memory locations, actually) to hold the factors of operations taking place. FAC1 and FAC2 are the primary accumulators; FAC3 operates as a temporary holding location. The results always appear in FAC1.

The first step in the BCD floating-point addition routine (see listing 1) is to align exponents (equivalent to aligning decimal points when adding numbers on paper). FADD moves the factor with the largest exponent into FAC1 and then subtracts exponents to determine how many times it is necessary to increment FAC2's exponent to align it with FAC1's. Incrementing FAC2's exponent is offset by dividing FAC2's mantissa by 10; actually, the exponent of FAC2 is never incremented since all that is needed is FAC2's adjusted mantissa. Once the two factors are aligned, FAC1 can provide the exponent, because both exponents are now equal.

This is where BCD floating-point numbers and binary floating-point numbers show their differences: A single shift of a binary floating-point mantissa multiplies or divides (depending on the direction of the shift) the number by 2. Shifting a BCD floating-point mantissa left (or right) by a nibble multiplies (or divides) that number by 10. See the symmetry? The operations are the same; only the bases have changed.

There is the possibility that, in order to align exponents, FADD might have to shift FAC2's mantissa to the right more times than FAC2 has significant digits. In other words, FAC2's magnitude may be negligible relative to FAC1's magnitude—at least within the accuracy of this BCD package. In this case, FADD simply exits without changing the contents of FAC1.

Once the exponents are equal (i.e., the decimal points are aligned), the routine can do the addition. Actually, it may not always be addition; the routine will need to do subtraction if the mantissas' signs are different. If the routine ends up subtracting the numbers, then, on the way out the door, it makes a final check to see if a borrow (subtraction's counterpart to addition's carry) has been generated. A borrow indicates that the sign of the result is opposite FAC1's sign; in other words, FAC1 was a positive number, and FAC2 is a negative number with an absolute value greater than FAC1. Since FAC1 now holds the result, the routine flips its sign accordingly. Finally, the FADD exits through the normalization routine.

Normalization

Normalization preserves a high accuracy for floating-point numbers. Simply put, when you normalize a floating-point number, you move its most-significant digit just to the right of the decimal point. Instead of storing 270 as $.00027 \times 10^6$ (and wasting space on all those zeros), you normalize the number and store it as $.27 \times 10^3$. So normalization simply boils down to multiplying or dividing the mantissa by powers of 10 while incrementing or decrementing the exponent, thereby leaving the value of the number unchanged. You've already seen that multiplication and division of the mantissa can be accomplished by shift operations. The pseudocode for normalization uses the same concepts and should therefore be pretty easy to understand (see listing 2).

Keep in mind that two memory representations of numbers are at play in this package: the internal representation (how the number is stored in the floating-point accumulators) and the external representation (how the number is stored in the local memory of an application). These representations are different, and for good reason. When numbers are be-

ing processed by the floating-point package, you are concerned primarily with maintaining accuracy. Space conservation is no real issue; at most, only two numbers are being manipulated at a time. Outside, in the application program that is calling the floating-point package, memory space may be a serious consideration.

For example, the number 0.4332198, normalized and stored in FAC1, would look like this:

```
0433 2198 0000 0000 0000 0000
```

Notice that when the number is in internal form, it is shifted to the right one digit. This leaves an empty "overflow" slot that catches any carries (or borrows) out of the most-significant-digit position. Also, the internal representation carries an extra word at the number's least-significant digits (see figure 1). This padding becomes important as numbers are shifted to the right to align exponents for the addition operation; some of the least-significant digits are retained, rather than being shifted off into never-never land.

Subtraction

This is as easy as ever: Flip the sign of FAC2 and call the FADD routine.

Multiplication

In multiplication, the speed advantage of a binary package over a BCD package begins to show through. Multiplication is actually a series of shift-and-add operations. In the binary floating-point package, an addition takes place for each 1 bit in the multiplier. But in this BCD package, the number of additions that takes place is equal to the sum of the multiplier's digits.

Let me illustrate. When the BCD package goes to multiply 15 and 34, it first sets up a product memory location, initialized to 0. Then, it looks at the rightmost digit of the multiplier (4 in this case), which indicates the number of times to add the multiplicand into the product. So the partial product in step 1 is 15+15+15+15=60. Then the routine examines the multiplier's next digit to the left (3), which is the number of times to add the multiplicand *times 10* into the partial product. So the result in this example is 60 + (150+150+150), or 510. For a bigger multiplier, this process would repeat with the multiplicand times 100, times 1000, and so on.

Put another way, the routine is repeatedly multiplying the multiplicand by 10

continued

Listing 2: *Normalizing a BCD floating-point number.*

```
{ Normalize the floating-point number in FAC1.
NORM_FAC1:
  IF FAC1_MAN = 0 THEN
    BEGIN
      FAC1_EXP := 0;
      FAC1_SGN := 0;
      RETURN no error;
    END
  IF highest nibble of FAC1_MAN <> 0 THEN
    BEGIN
      Shift FAC1_MAN right 1 nibble;
      FAC1_EXP := FAC1_EXP + 1;
      IF high bit of FAC1_EXP <> 0 THEN
        RETURN exponent overflow;
    END
  WHILE highest nibble of FAC1_MAN = 0
    BEGIN
      Shift FAC1_MAN left 1 nibble;
      FAC1_EXP := FAC1_EXP - 1;
    END
  IF high bit of FAC1_EXP <> 0 THEN
    RETURN exponent underflow;
  ELSE
    RETURN no error;
```

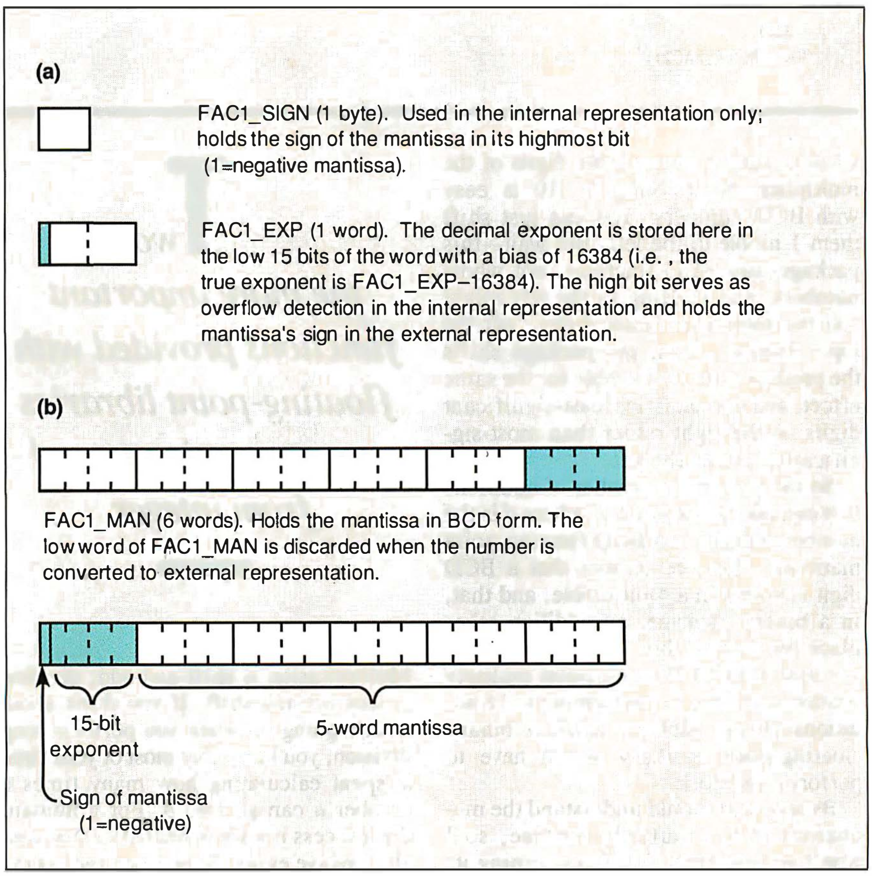


Figure 1: **(a)** *A BCD floating-point number's internal storage (i.e., when the floating-point package is operating on the number), and* **(b)** *its external storage, as seen by the calling application. This format can handle numbers in the range* $\pm n \times 10^{\pm 16383}$, *where* n *is a decimal fraction with 20 digits of precision.*

Listing 3: *Pseudocode for the multiplication algorithm.*

```
{ Multiply contents of FAC1 and FAC2. Result in FAC1.
FMUL:
  IF (FAC1_EXP = 0) OR (FAC2_EXP = 0) THEN
    BEGIN
      FAC1_MAN := 0;  { Clear the mantissa
      GOTO NORM_FAC1;
    END
  { Calculate exponent of result.
  FAC1_EXP := FAC2_EXP - BIAS + FAC1_EXP;
  IF high bit of FAC1_EXP = 1 THEN
     RETURN exponent overflow error;
  { Determine sign of the result.
  FAC1_SIGN := FAC2_SIGN XOR FAC1_SIGN;
  { Copy FAC1's mantissa to FAC3 and clear FAC1's mantissa in
  { preparation.
  Copy FAC1_MAN into FAC3_MAN;
  FAC1_MAN := 0;
  REPEAT number_of_digits times
    BEGIN
      N := lowest nibble of FAC3;
      REPEAT N times
        { NOTE: The following statement adds two BCD numbers.
        FAC1_MAN := FAC2_MAN + FAC1_MAN;
      IF this is not last time through REPEAT loop THEN
        BEGIN
          Shift FAC1_MAN right 1 nibble;
          Shift FAC3_MAN right 1 nibble;
        END
    END
  GOTO NORM_FAC1;
```

while scanning through the digits of the multiplier. Multiplying by 10 is easy with BCD numbers: You can just shift them 1 nibble to the left. But wait—this package uses BCD fractions, not whole numbers, and shifting to the left might roll the most-significant digits "off the top." Instead, then, the package shifts the product right by 1 nibble for the same effect, and you sacrifice least-significant digits on the right rather than most-significant digits on the left.

So the maximum number of additions that can take place is $9 \times d$, where d is the number of digits in a BCD floating-point mantissa. Now, remember that a BCD digit is stored in a 4-bit nibble, and that, in a binary package, an addition takes place for every 1 bit. You can see that, *per byte*, a BCD floating-point multiply routine may have to perform up to 18 additions (9 per nibble), while a binary floating-point multiply would have to perform 8 at most.

By now you should understand the mechanics of the multiply routine, so I won't go into great detail concerning its pseudocode in listing 3. About the only thing I've left out is how the routine determines the sign of the result. And that's easy: You do an EXCLUSIVE-OR on the signs of the two factors.

Two of the more important functions provided with floating-point libraries are conversion to and from integer.

Division

Multiplication is shift-and-add; division is subtract-and-shift. If you think about what's going on when you perform long division, you know that most of your time is spent calculating how many times a number a can go into b. For a human, this process is a set of heuristics that usually involve eying the number and taking educated guesses. For a computer, the process is cruder: Keep subtracting a from b until b is less than or equal to 0, and keep track of how many times you perform the subtraction. There—now you know the core of the division algorithm (see listing 4).

It is easy to dissect the other parts of the routine. To determine the sign of the quotient, you use the same technique as in the multiplication routine: You do an EXCLUSIVE-OR on the sign bytes of the factors. Make sure you're watching for a 0 in the denominator (FAC2 in this package), and bail out with an error condition if you see one. Finally, if the numerator (in FAC1) is 0, the routine can exit without having to do any work since the result is already in place.

Conversions

Two of the more important functions provided with floating-point libraries are conversion to and from integer. In the interest of completeness, I include them in this package.

Listing 5 shows the pseudocode for converting a 16-bit integer to a BCD floating-point number. This routine is primarily a process that pulls decimal digits out of the integer number one at a time, shifting each digit into the mantissa and incrementing the exponent for each digit shifted in. You can extract digits from an integer by repeatedly dividing that number by 10 and examining the remainder after each division.

Since a 16-bit number can hold, at most, five decimal digits, the routine need not concern itself with overflow checks. The only extra test is for the sign, at the start of the routine.

Getting a number back to integer from the floating-point format is another matter. There are two possible situations in which the conversion will fail. In case 1, the number is too large to fit into a 16-bit signed integer (whose range, by the way, is ±32767); in case 2, the number has no integer part—that is, it's something like 0.001.

Strictly speaking, case 2 doesn't cause a failure; the routine simply returns a 0 for the result. Handling case 1 is trickier. You can get a quick idea of whether or not the floating-point number will fit by examining its exponent. When FAC1_EXP −BIAS is a positive number, the result is the number of digits to the left of the decimal point. Consequently, if FAC1_EXP −BIAS is greater than 5, the routine can exit immediately: The number is surely too big. Otherwise, checking for overflow has to proceed as the number is converted to integer.

The routine multiplies an accumulator by 10, shifts the topmost digit out of the mantissa, and adds this digit to the accumulator. (The number of digits to shift

continued

Listing 4: *BCD floating-point division.*

```
{ Divide number in FAC1 by number in FAC2.
{ Leave the result in FAC1.
FDIV:
  IF FAC2_EXP = 0 THEN
    RETURN divide by zero error;
  { If FAC1 = 0, the result is zero.
  IF FAC1_EXP = 0 THEN
    RETURN no error;
  { Calculate the exponent of the quotient.
  FAC1_EXP := FAC1_EXP - FAC2_EXP + BIAS;
  { Determine the sign of the quotient.
  FAC1_SIGN := FAC1_SIGN XOR FAC2_SIGN;
  { Clear FAC3 to hold the result.
  FAC3_MAN := 0;
  REPEAT number_of_digits times
    BEGIN
      DO
      { NOTE: The following expression subtracts BCD numbers.
        FAC1_MAN := FAC1_MAN - FAC2_MAN;
        BORROW := TRUE if borrow is generated
               else FALSE;
        IF BORROW=FALSE THEN
          Increment lowest nibble in FAC3_MAN;
      WHILE BORROW=FALSE;
      BEGIN
        { Following is a BCD addition.
        FAC1_MAN := FAC1_MAN + FAC2_MAN;
        IF this is not last time through REPEAT loop THEN
        BEGIN
          Shift FAC1_MAN left 1 nibble;
          Shift FAC3_MAN left 1 nibble;
        END
      END
    END
  FAC1_MAN := FAC3_MAN;
  GOTO NORM_FAC1;
```

Listing 5: *Pseudocode for converting an integer to a floating-point number.*

```
{ Convert integer in IREG to a BCD floating-point number stored in
{ FAC1. NOTE: In this and the floating-to-integer routine, IREG is
{ assumed to hold a 16-bit signed integer.
INT_TO_FLOAT:
  IF IREG < 0 THEN
    FAC1_SIGN := 80H;
  ELSE
    FAC1_SIGN := 0;
  { Clear FAC1 to receive number.
  FAC1_EXP := 0;
  FAC1_MAN := 0;
  { Repeatedly divide IREG by 10. Capture each remainder into top
  { nibble of FAC1_MAN.
  WHILE IREG <> 0 DO
    BEGIN
      IREG := IREG / 10;
      High nibble of FAC1_MAN := remainder from
       previous division;
      Shift FAC1_MAN right 1 nibble;
      FAC1_EXP := FAC1_EXP + 1;
    END
  IF FAC1_EXP <> 0 THEN
    FAC1_EXP := FAC1_EXP + BIAS;
  GOTO NORM_FAC1;
```

BCDs and CPUs

Most microprocessors in use today include instructions specifically for manipulating binary-coded-decimal numbers. It's a devilish pain doing BCD mathematics if the CPU doesn't have some provision for them.

With the Intel 8088/80286/80386 family, you have to perform a "decimal adjust" on the AL register after an add or subtract operation. So, if I had two BCD numbers, one in AL and the other in BL, and I wanted to add these numbers, I would use the following:

```
ADD     AL,BL
DAA
```

where DAA is the instruction for "decimal adjust after addition." Similarly, if I were subtracting the numbers, the code would look something like the following:

```
SUB     AL,BL
DAS
```

You've probably guessed that DAS means "decimal adjust after subtraction." Notice that the instructions are almost afterthoughts: You tell the processor to perform an addition or subtraction, and it thinks you mean with binary numbers, so you have to tell it "No, they were really BCD numbers, so please go fix the results."

With Motorola's 68xxx family, the situation is a little better. Members of this family have special BCD addition and subtraction operations that don't require an additional cleanup step. To add two BCD numbers, you use the instruction ABCD; the mnemonic stands for "add two BCD bytes and the extend bit." (The extend bit is a kind of auxiliary carry.) As you might suspect, the instruction for subtracting BCD numbers is SBCD.

On both processors, BCD operations occur in byte-wide fashion; the engineers decided, for whatever reason, not to incorporate word-wide or double-word-wide BCD instructions. (On the Intel CPUs, the decimal-adjust instructions affect only the AL register.) This is a big contribution to a BCD package's disappointing speed.

out is given by FAC1_MAN−BIAS.) You can see by examining listing 6 that the function checks for overflow when the accumulator is multiplied by 10 and after each digit is added to the accumulator. If the number is successfully converted, the routine then finishes up by checking the contents of FAC1_SIGN; if the sign is negative, the accumulator is negated.

Optimizations

Right off, I can think of two ways to improve this package's execution speed. The first is in the multiplication routine. Remember that the number of additions performed is dependent on the sum of the digits of the multiplier. This means that if you are multiplying 11 by 99,394, the routine is going to go much faster if 11 is the multiplier (resulting in two additions) rather than 99,394 (resulting in 34 additions). Since it doesn't matter which factor is in which accumulator (by the commutative law), you could easily add a routine that sums the digits of both factors and moves the number with the lowest result into the multiplier's place (FAC1).

In the division algorithm, you might be able to squeeze out some extra performance by watching for the case where the dividend is an even multiple of the divisor. This would occur if the subtraction yields a result of zero. If this happens, you could halt all further subtractions and simply continue the shift operations—the subtractions would shift zeros into the quotient anyway. This optimization might not be as effective as the previous one, since a dividend will probably rarely be an even multiple of the divisor.

To BCD or not to BCD

A BCD floating-point package carries some features not found in a similar binary package. In particular, a BCD package is often the mathematics package of choice for business applications, thanks to a BCD number's immunity to conversion between the internal number and what is ultimately displayed or printed. Also, since a BCD floating-point's exponent represents a power of 10, you can represent much bigger (and much smaller) numbers than with a binary floating-point package.

Still, there are trade-offs. As I've shown, the four basic operations execute more slowly using BCD numbers, and it's simpler to make a binary package

continued

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Listing 6: *Converting a floating-point number to its integer equivalent.*

```
{ Convert floating-point number in FAC1 to integer in IREG.
FLOAT_TO_INT:
  IREG := 0;    { Prepare the way.
  { See if number has any integer part at all.
  IF FAC1_EXP <= BIAS THEN
    RETURN no error;
  { Can IREG hold the number?
  IF (FAC1_EXP - BIAS) > 5 THEN
    RETURN overflow error;
  REPEAT (FAC1_EXP - BIAS) TIMES
    BEGIN
      IREG := IREG * 10;
      IF result of multiplication has greater
       than 15 bits of precision THEN
        RETURN overflow error;
      Shift FAC1_MAN left 1 nibble;
      N := highmost nibble in FAC1_MAN;
      IREG := IREG + N;
      IF high bit of IREG = 1 THEN
        RETURN overflow error;
   END
   IF FAC1_SIGN = 80H THEN
     Negate IREG;
   RETURN no error;
```

compatible with a floating-point coprocessor. Ultimately, the application will determine which package you use. Since I've provided both BCD and binary packages for your programming toolkits, you should have all you need to choose the right tool for the job.

Next Month

An inside look at something we all have to live with: file directories. ■

Editor's note: *The listings printed with this column are pseudocode and are intended to represent the concepts and flow of the actual 80x86 assembly language, which is available in a variety of formats. See page 3 for details.*

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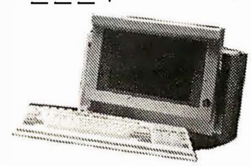
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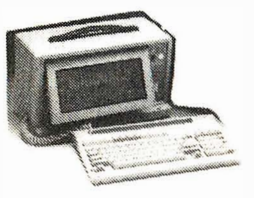


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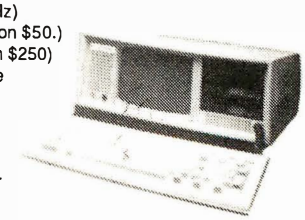
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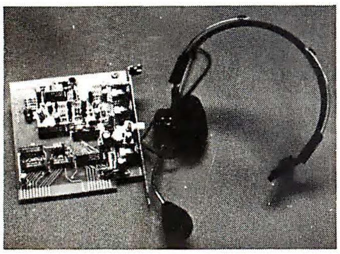
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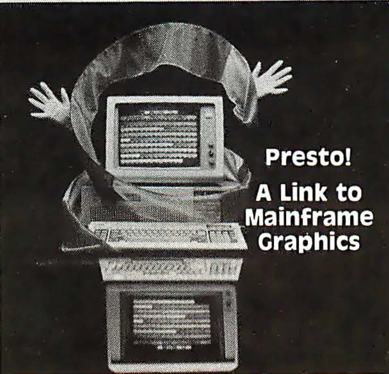
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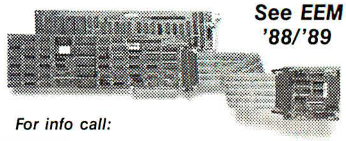
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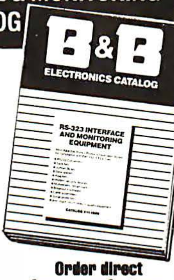
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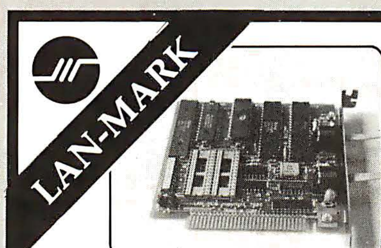
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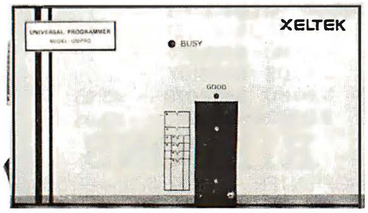
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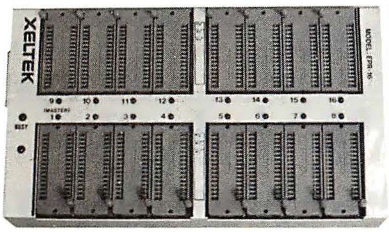
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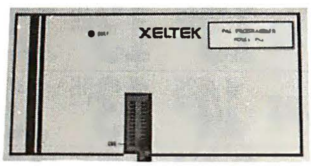
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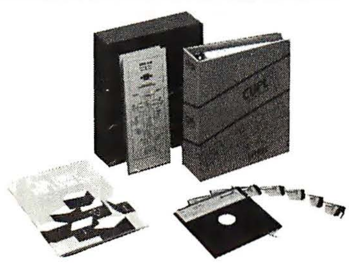
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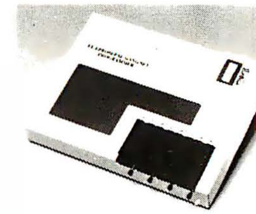
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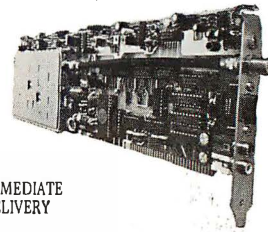
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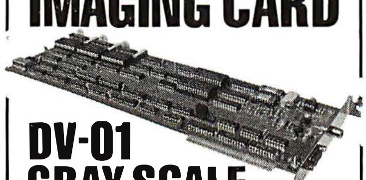
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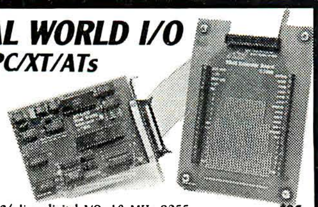
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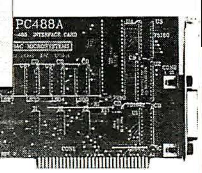
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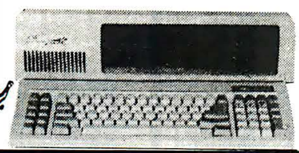
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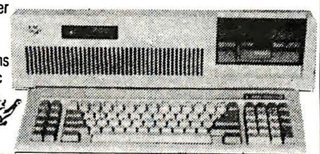
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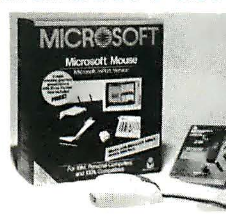
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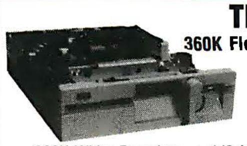
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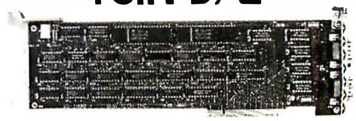
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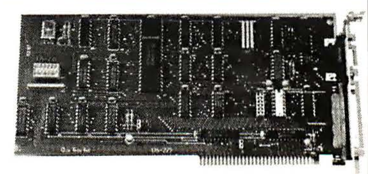
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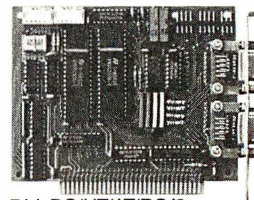
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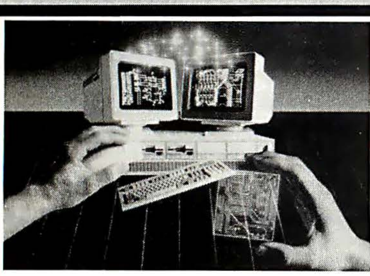
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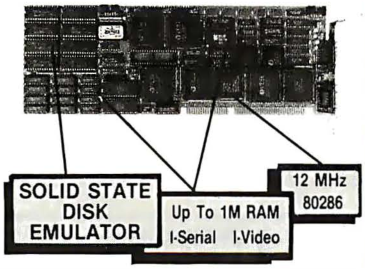
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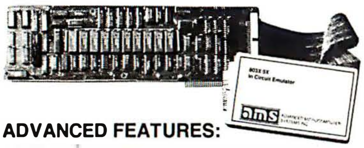
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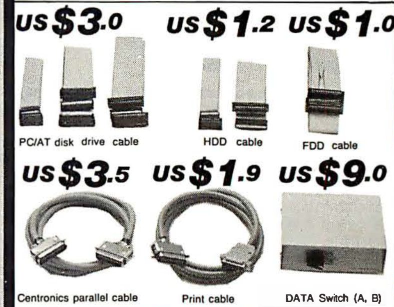
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8748H (HMOS) (21V)	9.95
8749	9.95
8751 (3.5-8MHz)	37.95
8751H (3.5-12MHz)	39.95
8755	~~13.95~~ 12.95
80286-10 LCC	59.95
80287 (6MHz)	159.95
80287-8 (8MHz)	229.95
80287-10 (10MHz)	279.95
80386-16 PGA	309.95
80387-16 (16MHz)	439.95
80387-20 (20MHz)	499.95
80387-25 (25MHz)	599.95
80387-SX (16MHz)	399.95
82284 (8MHz)	9.49
82288 (8MHz)	9.95

DATA ACQUISITION

ADC0804LCN	2.79
ADC0808CCN	~~5.95~~ 5.49
ADC0809CCN	~~3.69~~ 3.29
ADC1205CCJ-1	19.95
DAC0808LCN	~~1.75~~ 1.49
DAC1008LCN	5.95
AY-3-1015D	~~4.95~~ 3.95
AY-5-1013A	1.95

STATIC RAMS

Part No.	Function		Price
2016-12	2048x8	120ns	~~4.95~~ 3.75
2018-45	2048x8	45ns 300MIL	6.95
2102	1024x1	350ns	.89
2114N	1024x4	450ns	~~.99~~ .79
2114N-2L	1024x4	200ns Low Power	1.49
21C14	1024x4	200ns (CMOS)	.49
5101	256x4	450ns (CMOS)	~~2.95~~ 2.49
6116P-1	2048x8	100ns (16K) CMOS	~~6.25~~ 3.95
6116P-3	2048x8	150ns (16K) CMOS	~~4.95~~ 3.49
6116LP-1	2048x8	100ns (16K) LP CMOS	~~6.49~~ 4.39
6116LP-3	2048x8	150ns (16K) LP CMOS	~~5.99~~ 3.95
6264P-10	8192x8	100ns (64K) CMOS	~~10.49~~ 9.95
6264P-15	8192x8	150ns (64K) CMOS	9.25
6264LP-10	8192x8	100ns (64K) LP CMOS	10.95
6264LP-12	8192x8	120ns (64K) LP CMOS	10.49
6264LP-15	8192x8	150ns (64K) LP CMOS	10.25
6514	1024x4	350ns (CMOS)	~~3.75~~ 3.49
43256-10L	32,768x8	100ns (256K) Low Power	20.95
43256-15L	32,768x8	150ns (256K) Low Power	18.95
62256LP-85	32,768x8	85ns (256K) LP CMOS	22.95
62256LP-10	32,768x8	100ns (256K) LP CMOS	21.95
62256LP-12	32,768x8	120ns (256K) LP CMOS	20.95

DYNAMIC RAMS

THM91000L-10	1,048,576x9	100ns 1Megx9 SIP	~~549.95~~ 399.95
THM91000S-10	1,048,576x9	100ns 1Megx9 SIM	399.95
THM91000L-80	1,048,576x9	80ns 1Megx9 SIP	419.95
THM91000S-80	1,048,576x9	80ns 1Megx9 SIM	419.95
TMS4416-12	16,384x4	120ns	~~7.75~~ 6.75
TMS4416-15	16,384x4	150ns	~~7.25~~ 6.25
4116-15	16,384x1	150ns (MM5290N-2)	~~1.39~~ 1.25
4128-15	131,072x1	150ns (Piggyback)	5.29
4164-100	65,536x1	100ns	3.49
4164-120	65,536x1	120ns	2.95
4164-150	65,536x1	150ns	2.59
41256-60	262,144x1	60ns	14.49
41256-80	262,144x1	80ns	13.49
41256-100	262,144x1	100ns	12.49
41256-120	262,144x1	120ns	11.95
41256-150	262,144x1	150ns	11.49
41264-12	64Kx4	120ns Video RAM	19.95
41464-10	65,536x4	100ns	~~15.95~~ 14.49
41464-12	65,536x4	120ns	~~14.49~~ 11.95
41464-15	65,536x4	150ns	~~13.95~~ 10.95
51258-10	262,144x1	100ns Static Column	13.95
85227-10PL	262,144x9	100ns 256Kx9 SIP	149.95
85227-10PS	262,144x9	100ns 256Kx9 SIM	149.95
511000P-10	1,048,576x1	100ns (1 Meg)	~~39.95~~ 29.95
511000P-80	1,048,576x1	80ns (1 Meg)	42.95
511000P-85	1,048,576x1	85ns (1 Meg)	~~44.95~~ 41.95
514256P-10	262,144x4	100ns (1 Meg)	~~44.95~~ 34.95

EPROMS

TMS2516	2048x8	450ns (25V)	~~6.95~~ 5.95
TMS2532	4096x8	450ns (25V)	~~6.95~~ 4.95
TMS2532A	4096x8	450ns (12.5V)	~~4.49~~ 3.25
TMS2564	8192x8	450ns (25V)	~~6.95~~ 4.95
TMS2716	2048x8	450ns (−5V, +5, +12V)	~~6.95~~ 6.49
1702A	256x8	(1μs)	4.95
2708	1024x8	450ns	6.95
2716	2048x8	450ns (25V)	3.75
2716-1	2048x8	350ns (25V)	~~4.25~~ 3.95
27C16	2048x8	450ns (25V) CMOS	~~4.25~~ 3.75
2732	4096x8	450ns (25V)	3.95
2732A-20	4096x8	200ns (21V)	4.25
2732A-25	4096x8	250ns (21V)	3.95
27C32	4096x8	450ns (25V) CMOS	~~4.95~~ 4.25
2764-20	8192x8	200ns (21V)	4.25
2764-25	8192x8	250ns (21V)	3.59
2764-45	8192x8	450ns (21V)	3.39
2764A-25	8192x8	250ns (12.5V)	3.69
27C64-15	8192x8	150ns (12.5V) CMOS	5.95
27128-20	16,384x8	200ns (21V)	~~6.95~~ 6.49
27128-25	16,384x8	250ns (21V)	5.95
27128A-15	16,384x8	150ns (12.5V)	7.75
27128A-20	16,384x8	200ns (12.5V)	~~5.75~~ 5.25
27128A-25	16,384x8	250ns (12.5V)	~~5.25~~ 4.95
27C128-25	16,384x8	250ns (21V) CMOS	5.95
27256-15	32,768x8	150ns (12.5V)	8.95
27256-20	32,768x8	200ns (12.5V)	~~6.95~~ 6.25
27256-25	32,768x8	250ns (12.5V)	5.49
27C256-15	32,768x8	150ns (12.5V) CMOS	7.95
27C256-25	32,768x8	250ns (12.5V) CMOS	~~6.25~~ 5.49
27512-20	65,536x8	200ns (12.5V)	10.95
27512-25	65,536x8	250ns (12.5V)	9.95
27C512-25	65,536x8	250ns (12.5V) CMOS	~~10.25~~ 9.49
27C1024	131,072x8	200ns (12.5V) CMOS (1 Meg)	27.95

6500/6800 68000 Series

Part No.	Price
6502	2.65
65C02 (CMOS)	7.75
6520	1.95
6522	2.95
6532	~~5.49~~ 4.95
6551	2.95
65C802 (CMOS)	~~15.95~~ 14.75
6800	~~1.95~~ 1.49
6802	2.95
6810	~~1.25~~ .99
6821	1.75
6840	~~3.49~~ 2.95
6845	~~2.75~~ 2.49
6850	~~1.95~~ 1.49
6852	~~.75~~ .59
6854	~~1.19~~ .99
MC68000L8	9.95
MC68000L10	~~11.95~~ 10.95
MC68010L10	~~49.95~~ 39.95
MC68020RC12B	99.95
MC68701	14.95
MC68705P3S	~~9.95~~ 8.95
MC68705U3L	10.95
MC68705U3S	10.95
MC68450L10	49.95
MC68881RC12A	129.95

Commodore

LAG570	9.95
WD1770	~~8.95~~ 7.49
SI3052P	~~1.25~~ .99
6504A	1.19
6507	2.95
6510	12.95
6522	2.95
6525	~~4.95~~ 3.95
6526	~~14.95~~ 13.95
6532	~~5.49~~ 4.95
6545-1	3.95
6560	~~10.95~~ 8.95
6567	24.95
6569	~~15.95~~ 13.95
6572	~~10.95~~ 7.95
6581 (12V)	~~12.95~~ 10.49
6582 (9V)	~~14.95~~ 12.95
8502	7.95
8564	~~4.95~~ 2.95
8566	~~9.95~~ 7.95
8701	9.95
8721	~~14.95~~ 9.95
8722	~~13.95~~ 10.95
310654-05	9.95
318018-03	~~12.95~~ 10.95
318019-03	~~12.95~~ 10.95
*82S100PLA**	15.95
901225-01	~~15.95~~ 13.95
901226-01	~~15.95~~ 13.95
901227-03	15.95
901229-05	15.95

*No specs. available
**Note: 82S100PLA = U17 (C-64)

74C/CMOS

74C00	Sale	.19	74C174	Sale	.39
74C02	Sale	.19	74C175	Sale	.59
74C04	Sale	.19	74C192	Sale	.99
74C08	Sale	.19	74C194	Sale	.49
74C10	Sale	.15	74C221		1.79
74C14		.49	74C240	Sale	.75
74C32	Sale	.19	74C244		1.79
74C74		.49	74C373	Sale	1.49
74C85		1.49	74C374	Sale	1.49
74C86	Sale	.19	74C911		6.95
74C89		2.95	74C912	Sale	7.95
74C90		.99	74C915	Sale	1.19
74C151	Sale	1.49	74C917	Sale	3.95
74C154	Sale	2.75	74C920	Sale	3.95
74C157	Sale	1.25	74C921	Sale	2.95
74C160	Sale	.49	74C922		3.95
74C161	Sale	.49	74C923		3.95
74C162	Sale	.49	74C925		5.49
74C173		.59	74C926		5.95

MISC. COMPONENTS

TANTALUM CAPACITORS

TM.1/35	.1μf @ 35V	.19	TM4.7/35	4.7μf @ 35V	.45
TM1/35	1μf @ 35V	.19	TM6.8/35	6.8μf @ 35V	.49
TM2.2/35	2.2μf @ 35V	.25	TM10/35	10μf @ 35V	.59

POTENTIOMETERS

Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX	¾ Watt, 15 Turn	.99	63PXX	½ Watt, 1 Turn	.89

TRANSISTORS AND DIODES

PN2222	.13	PN2907	.13	1N4004	.12
2N2222A	.29	2N4401	.12	1N4148	.07
2N3055	.65	1N270	.25	1N4735	.29
2N3904	.12	1N751	.15	C106B1	.49

SWITCHES

JMT123	SPDT, On-On	1.19	206-8	SPDT, 16-pin DIP	1.25
MPC121	SPDT, On-Off-On	1.19	MS102	SPST, Momentary	.39

D-SUB CONNECTORS

DB25P	Male, 25-pin	.69	DB25S	Female, 25-pin	.75

LEDS

XC556R	T1¾, Red	.13	XC556Y	T1¾, Yellow	.17
XC556G	T1¾, Green	.17	XC556C	T1¾, Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

74HC HI-SPEED CMOS

Part No.		Price	Part No.		Price
74HC00	SALE	.17	74HC175		.59
74HC02	SALE	.17	74HC221	SALE	.69
74HC04	SALE	.17	74HC240	SALE	.59
74HC08	SALE	.17	74HC244		.79
74HC10	SALE	.19	74HC245	SALE	.69
74HC14		.29	74HC253	SALE	.39
74HC30	SALE	.19	74HC259		.49
74HC32	SALE	.25	74HC273	SALE	.49
74HC74	SALE	.29	74HC373		.69
74HC75	SALE	.29	74HC374	SALE	.59
74HC76	SALE	.29	74HC595		1.29
74HC85		.55	74HC688	SALE	1.25
74HC86	SALE	.25	74HC943	SALE	7.95
74HC123	SALE	.49	74HC4040	SALE	.79
74HC125		.49	74HC4049	SALE	.25
74HC132	SALE	.39	74HC4050	SALE	.25
74HC138		.45	74HC4060	SALE	.69
74HC139	SALE	.35	74HC4511	SALE	.99
74HC154		1.49	74HC4514		1.79
74HC163	SALE	.39	74HC4538	SALE	.99
74HC174		.59	74HC4543	SALE	.99

74HCT — CMOS TTL

74HCT00	SALE	.15	74HCT139	SALE	.29
74HCT02	SALE	.15	74HCT157	SALE	.19
74HCT04	SALE	.17	74HCT174	SALE	.25
74HCT08	SALE	.15	74HCT175	SALE	.25
74HCT10	SALE	.15	74HCT240	SALE	.59
74HCT32	SALE	.17	74HCT244	SALE	.49
74HCT74	SALE	.25	74HCT245	SALE	.49
74HCT86	SALE	.15	74HCT373	SALE	.45
74HCT138		.39	74HCT374	SALE	.45

LINEAR

DS0026CN	1.95	LM1458N	.35
TL074CN	.99	LM1488N	.45
TL084CN	.89	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.45
LM307N	.39	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.69
LM311N	.39	MC1648P	2.95
LM317T	.65	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	1.49
LM323K	3.49	ULN2003A	.75
LM324N	.35	XR2206	3.95
LM338K	4.49	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.49	26LS29	2.95
LM348N	.69	26LS31	.99
LM350T	2.95	26LS32	.99
LF351N	.39	26LS33	1.49
LF353N	.49	LM2901N	.25
LF355N	.79	LM2907N	1.29
LF356N	.79	LM2917N (8 pin)	1.79
LF357N	.89	MC3446N	.99
LM358N	.49	MC3450P	.49
LM360N	1.95	MC3470P	1.19
LM361N	1.49	MC3471P	.99
LM380N-8	.99	MC3479P	3.95
LM386N-3	.89	MC3486P	1.19
LM387N	1.09	MC3487P	.99
LM393N	.39	LM3900N	.49
LM399H	3.49	LM3905N	1.19
LF411CN	.79	LM3909N	.89
TL497ACN	1.49	LM3914N	1.79
NE540H (C540H)	.99	LM3916N	1.49
NE555V	.29	NE5532	.69
XRL555	.59	NE5534	.69
LM556N	.45	7805K (LM340K-5)	1.29
NE558N	.79	7812K (LM340K-12)	1.29
LM565N	.89	7815K (LM340K-15)	1.29
LM567V	.75	7805T (LM340T-5)	.45
NE592N	.75	7812T (LM340T-12)	.45
LM741CN	.29	7815T (LM340T-15)	.45
LM747CN	.49	7905K (LM320K-5)	1.35
MC1350P	.89	7905T (LM320T-5)	.49
MC1377P	2.29	75472	.49
MC1398P	4.95	75477	.89
LM1414N	.99	MC145106P	1.95
		MC145406P	2.95

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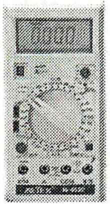
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TEST EQUIPMENT

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M4650 Pictured

Metex General Specs:
• Handheld, high accuracy
• AC/DC Voltage, AC/DC Current, Resistance, Diodes, Continuity, Transistor hFE • Manual ranging w/overload protection
M3650/B & M4650 only:
• Also measures frequency and capacitance
M4650 only:
• Data Hold Switch
• 4.5 Digit

M3610	3.5 Digit Multimeter	$49.95
M3650	3.5 Digit w/Freq. & Capacitance.	$69.95
M3650B	Same as M3650 w/Bargraph	$79.95
M4650	4.5 Dig. w/Freq., Capacitance and Data Hold Switch	$99.95

Metex Autoranging Jumbo Readout DMM

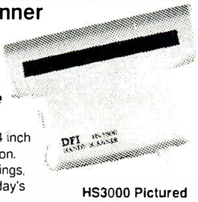


• AC/DC Voltage, AC/DC Current, Resistance, Diodes, Continuity and Frequency
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M80....................$59.95

COMPUTER ACCESSORIES

DFI Handy Scanner and 3 Button Mice for IBM PC/XT/AT

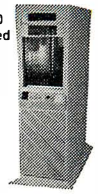

HS3000 Pictured

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DMS200	200DPI 3-Button Ser. Mouse	$49.95
DMS200S	200DPI 3-Button Ser. Mouse with Dr. Halo Software	$59.95

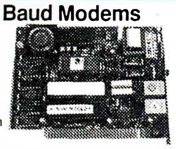
Additional IBM Compatible Accessories


JE2010 Pictured


JE1030 Pictured

JE1010	Flip-Top Standard PC/XT Case	$34.95
JE1014	Flip-Top Baby XT Turbo Case	$69.95
JE1017	Flip-Top Baby AT Case ~~$69.95~~	$54.95
JE1018	Slide Baby AT Case ~~$69.95~~	$59.95
JE1030	150 watt PC/XT Power Supply	$59.95
JE1032	200 watt Baby AT Power Supply	$89.95
JE2010	Tower Case w/250 watt Pwr. Supply	$299.95

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• Hayes command compatible
• Bell 103/212A compatible
• Auto-dial/auto-answer • FCC approved • 1-year warranty • Includes MaxiMite Communication Software (except 1200P)

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1200C	1200/300 Baud External Modem	$99.95
2400C	2400/1200/300 External Modem	$169.95

Jameco 12MHz IBM AT Compatible Kit With 512K RAM

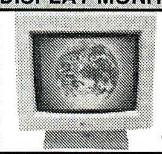
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Shown with EGA Option (not included)
JE1059 Monitor and Adapter Card $519.95 (See Below)

JE3008	12MHz IBM AT Compatible Kit	$799.95
EZDOS	Digital Research MS/PC-DOS Comp. Operating Sys.	$49.95
EZDOSP	Same as above with TrueBASIC	$69.95

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AMBER	12" Amber Mono.	$99.95
CTX2410	14" RGB 640x200	$279.95
TM5154	EGA 14" 720x350	$399.95
JE1059	EGA Monitor & Card	$519.95
TM5155	14" Multiscan 800x560	$499.95
QC1478	14" VGA 720x480	$449.95
JE2055	VGA Monitor & Card	$649.95


NEW
QC1478 Pictured

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JE1044	360K Floppy/Hard Disk Controller Card (PC/XT)	$129.95
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JE1050	Monochrome Graphics Card w/Parallel Printer Port (PC/XT/AT)	$59.95
JE1052	Color Graphics Card w/Parallel Printer Port (PC/XT/AT)	$49.95
JE1055	EGA Card w/256K Video RAM (PC/XT/AT)	$159.95
GC1500	Orchid 8-Bit VGA Card w/256K Video RAM (PC/XT/AT)	$269.95
GC1501	Orchid 8/16-Bit VGA Card w/256K Video RAM (PC/XT/AT)	$349.95
JE1060	I/O Card w/Serial, Game, Printer Port & Real Time Clock (PC/XT)	$59.95
JE1061	RS232 Serial Half Card (PC/XT)	$29.95
JE1062	RS232 Serial Half Card (AT)	$34.95
JE1065	I/O Card w/Serial, Game and Parallel Printer Port (AT)	$59.95
JE1071	Multi I/O Card w/Controller & Monochrome Graphics (PC/XT)	$119.95
JE1081	2MB Expanded or Extended Memory Card (zero-K on-board) (AT)	$119.95

SEAGATE HALF-HEIGHT HARD DISK DRIVES

ST225	20MB Drive only (PC/XT/AT)	$224.95
ST225XT	20MB w/Controller (PC/XT)	$269.95
ST225AT	20MB w/Controller (AT)	$339.95
ST238	30MB Drive only (PC/XT/AT)	$249.95
ST238XT	30MB w/Controller (PC/XT)	$299.95
ST238AT	30MB w/Controller (AT)	$389.95
ST251	40MB Drive only (PC/XT/AT)	$379.95
ST251XT	40MB w/Controller (PC/XT)	$419.95
ST251AT	40MB w/Controller (AT)	$489.95
ST251-1	40MB Fast 28ms (Drive only)	$469.95

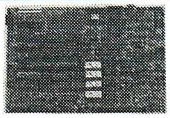
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ST225XT Pictured

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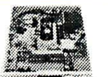
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JE3025	Baby 20MHz 80386 (AT)	$1499.95
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JE3025 Pictured

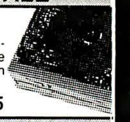
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JE1022 Pictured

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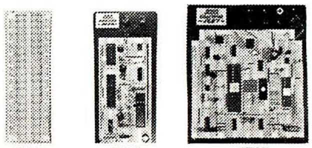


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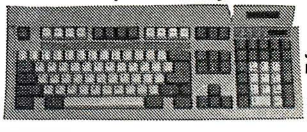
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JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
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JE23	6.5x2.125	830	0	$7.95
JE24	6.5x3.125	1,360	2	$12.95
JE25	6.5x4.25	1,660	3	$19.95
JE26	6.875x5.75	2,390	4	$24.95
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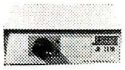
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Jameco IBM PC/XT/AT Compatible Keyboards


JE2016 Pictured

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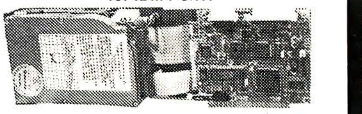
Jameco Switch Boxes


JE1170 Pictured

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• All Pins Switched

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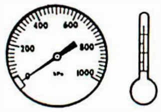
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A-BUS™ NEWS

REMOTE DATA ACQUISITION AND CONTROL



Although affordable, powerful and easy to use, the A-BUS I/O system until recently had a major limitation: it had to be located close to the controlling computer. Now two new serial adapters from Alpha Products have removed this restriction. Any computer with an RS232 port can control the A-BUS line of data acquisition and control cards.

Using standard telephone type cable, the A-BUS system can be located up to 500 feet away from the computer. With the addition of a Modem the A-BUS system can be controlled from anywhere. As with all A-BUS cards, the adapters are easily installed and are programmed using standard commands.

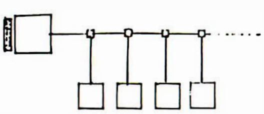
NEW SERIAL PROCESSOR HAS BRAIN



Besides implementining a full A-BUS on a serial port, the low cost SP-127 A-BUS Serial Processor fills a great need in remote data acquisition. It includes a complete BASIC interpreter and can run programs independently of the host computer. This distributed processing relieves the host of housekeeping chores and low level decision making. The SP-127 can read and log data at set intervals for later reviewing or recalling at the host's convenience.

The Serial Processor, which communicates with any computer through an RS232 port, includes a complete BASIC interpreter and 32K of memory. Adding a Modem turns the SP-127 into a automated remote data and control station.

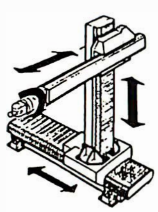
THE A-BUS ON NETWORK



Unique features such as the new "Serial Nodes" greatly expand the usefulness of the A-BUS. These inexpensive ($49) devices provide the ability to connect up to 16 complete A-BUS systems to a single serial port on any computer. The node also functions as a repeater to increase the reach of the adapter beyond the 500 foot limit

The nodes work in conjunction with the company's SA-129 Serial A-BUS Adapter. Plant-wide data collection and control will become widespread thanks to the system's low cost, outstanding capabilities, and ease of use.

ADVANCE IN MOTION CONTROL



Seeking new heights in motion control and robotics, Alpha's Smart Quad Stepper Controller outperforms systems costing 5-10 times more. This $299 board includes a multitasking microprocessor capable of controlling 4 stepper motors simultaneously at speeds up to 1000 steps per second. Four Axis positioning is perfect for robot arms, positioners, pick and place, etc.

Commands are intuitive; plain English words and a forgiving syntax make it easy to write (and edit) command sequences. Scaling factors allow for meaningful units of your choice, and 32 bit floating point arithmetic ensures accurate calculations. The "learn" feature involves storing a series of movements so that even a complex sequence can be repeated easily. Alpha's engineers thoughtfully included direct drivers for small motors, and a variety of inputs (limit switches, remote keypad, panic button, etc.).

An SC-149 can be set up quickly and easily, minimizing development time and allowing more effort to be devoted to the rest of the robotic project.

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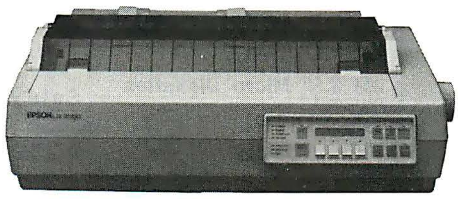
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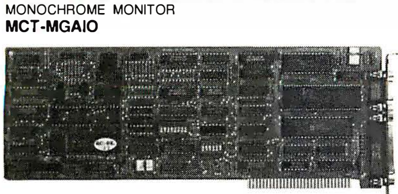
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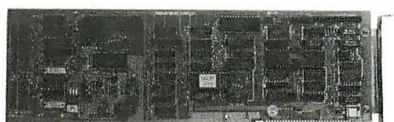
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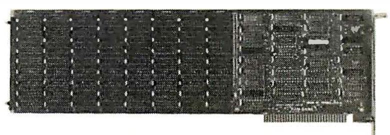
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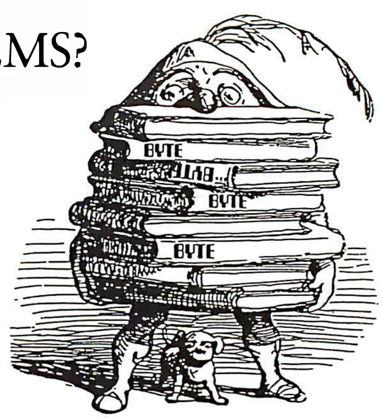
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Index of companies covered in articles, columns, or news stories in this issue
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COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

In **the front** of the May BYTE will be Microbytes, What's New, and Short Takes. May's Short Takes will include MultiBoot, an OS/2 booting utility from Bolt Systems; Compaq's external hard disk drive subsystem; Connectix's Virtual, a program that provides 8 megabytes of virtual RAM for the Macintosh II; Lotus's Magellan; and Disk Technician Advanced, an upgraded hard disk drive test and analysis program from Prime Solutions.

May's **Product Focus** will be on three-dimensional CAD software. These ever-more-capable programs on microcomputers are getting more popular all the time. Find out the state of the art in this article.

System reviews will consider two hand-held computers, Sharp's Wizard and Psion's Organiser II. Also on the list is a comparison of the Tandon and FiveStar systems featuring removable disk cartridges.

A couple of **hardware reviews** are a comparison of add-in facsimile cards for the Mac and a comparison of TrueScan and OmniPage scanners.

Software reviews concentrate on JPI's TopSpeed Modula-2 and Logic Gem from Sterling Castle; **application reviews** deal with Samna's Ami, a plethora of statistical analysis packages for the Mac, and Crowninshield Software's MediaBase.

IN DEPTH:

Unix, once obscure and often difficult, is enjoying something of a flowering of popular appreciation. With increased attention to easily absorbed user interfaces, more people are coming to know its speed and power. Our May In Depth section looks at Unix shells, Unix communications, Unix security, new incarnations of Unix, and making the changeover from DOS.

FEATURES:

Our May lineup of **columnists** begins with the Expert Advice group in the front of the book: Jerry Pournelle's Computing at Chaos Manor, Ezra Shapiro's Applications Plus, Wayne Rash's Down to Business, Brock N. Meek's COM1:, Don Crabb's Macinations, and Mark Minasi's OS/2 Notebook. Back in the Features section, under the heading Hands On, our two columns are Brett Glass's Under the Hood and Rick Grehan's Some Assembly Required.

In addition, we'll have a feature that analyzes the latest advancement in microcomputing science, **quantum technology**. While standard microcomputing manufacturing techniques are starting to reach physical size and speed limits imposed by the physics of electron flow, quantum technology offers improvements that are measured in orders of magnitude. If we've been waiting for the emergence of the next "breakthrough" technology, this may well be it.

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7a) When TIPS says "Enter (next) Inquiry Number"
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b) Repeat 7a as needed (maximum 17 inquiry numbers)

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4 ☐ Product Design and Development
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6 ☐ Manufacturing
7 ☐ Sales/Marketing
8 ☐ Purchasing
9 ☐ Personnel
10 ☐ Education/Training
11 ☐ Other: ______________

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2 ☐ Computer Retail Stores
3 ☐ Consultants
4 ☐ Service Bureau/Planning
5 ☐ Distributor/Wholesaler
6 ☐ Systems House/ Integrator/VAR
7 ☐ Other: ______________

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12 ☐ Government
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